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HIGH ORDER PARAMETRIC X-RADIATION FROM SILICON AND LITHIUM FLUORIDE CRYSTAL MONOCHROMATORS

by

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13. ABSTRACT

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HIGH ORDER PARAMETRIC X-RADIATION FROM SILICON AND LITHIUM FLUORIDE CRYSTAL MONOCHROMATORS

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I. INTRODUCTION

The need for sources of intense monochromatic x-rays has led to the study of the interaction of relativistic charged particles in various materials. Different mechanisms of generating x-rays are compared by Baryshevsky and Feranchuk [Ref. 1]. Parametric x-radiation (PXR) may be an important source of intense, monochromatic x-rays. PXR is the scattering of virtual photons associated with a relativistic charged particle, by the atomic planes of a crystal lattice at the Bragg or Laue condition. Ter-Mikaelian first developed the theory of PXR for thin crystals [Ref. 2] which was expanded by Feranchuck and Ivashin to include thick crystals [Ref. 3]. The first experimental verification of the theory of PXR was conducted in the Soviet Union by Baryshevsky, et. al., using the 900 MeV electron beam at the Tomsk synchrotron [Ref. 4].

The first experimental observation of PXR outside the Soviet Union was at the Naval Postgraduate School (NPS) using a 100 MeV electron linear accelerator. The first experiments were done using thin silicon crystals and carbon graphite mosaic crystals. [Ref. 5]

This thesis explores the energy and intensity ratio relationship between the PXR peaks generated by four different thicknesses of silicon crystals and compares these results to the peak relationships predicted by theory. The generation of PXR from a lithium fluoride crystal is observed for the first time in these experiments. These measurements are also compared to the values predicted by theory.

II. THEORETICAL BACKGROUND

A. PARAMETRIC X-RADIATION (PXR)

Parametric x-rays (PXR) are generated when a relativistic charged particle interacts with a crystal's periodic dielectric constant. Ter-Mikaelian described the radiation produced by a thin periodic crystal. [Ref. 2] PXR occurs in crystals thicker than the x-ray extinction length,

$$\kappa L \,|\, n-1 \,|\, \geq 1 \tag{1}$$

where L is the crystal thickness, κ is the emitted photon wave number and n is the crystal index of refraction [Ref. 6]. When an ultrarelativistic electron ($E \gg mc^2$) enters a crystal its electromagnetic field can be represented as a superposition of virtual photons. The electromagnetic interaction of ultrarelativistic electrons within a crystal is equivalent to the interaction of a photon beam within the crystal. PXR can be considered the result of virtual photon diffraction in the crystal [Ref. 6]. To analyze the interaction of virtual photons in a crystal we can use the results from the theory of X-ray diffraction and resonant γ-radiation. It is convenient to use natural units with $\hbar = c = 1$. In the ultrarelativistic electron case the virtual photon momentum can be written as,

$$\boldsymbol{\kappa} = \omega \frac{\mathbf{v}}{v^2} \approx \omega \mathbf{v} \tag{2}$$

where $\mathbf{v}$=the velocity and ω=the virtual photon frequency. The virtual photons whose momenta satisfy the Bragg condition

$$(\boldsymbol{\kappa} + \boldsymbol{\tau})^2 \approx \kappa^2 \tag{3}$$

are diffracted by the crystal, where τ is the reciprocal lattice vector. This leads to PXR in the $(\kappa+\tau)$ direction as shown in Figure 1. The photons are emitted from the crystal at an angle not dependant on the energy but at an angle defined by the particle's angle relative to the crystallographic plane. [Ref. 6].

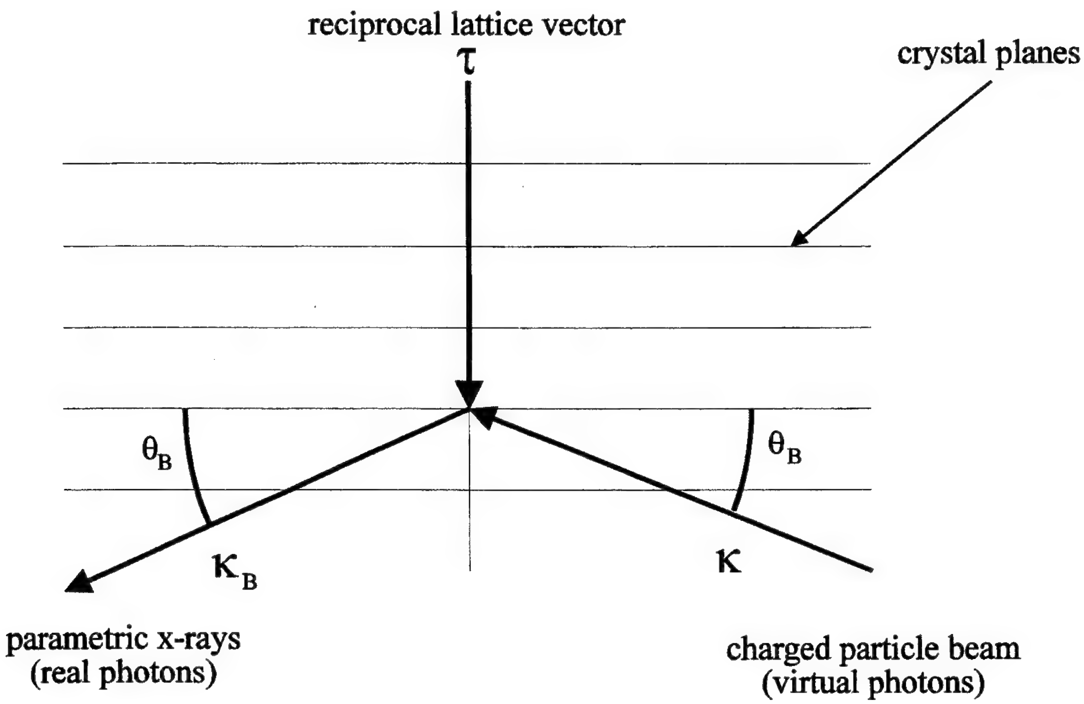


Figure 1. Parametric X-rays produced by diffraction of virtual photons by the planes of a crystal lattice.

1. PXR Energy

The emitted photon energy E, is calculated using Bragg's Law as follows;

$$n\lambda = 2d\sin\theta_B \,, \qquad E = \frac{hc}{\lambda} \tag{4}$$

$$E = \frac{nhc}{2d\sin\theta_B}, \tag{5}$$

using conventional units, where n=the order of the reflection, λ=the wavelength of the

emitted photon, d=the distance between crystal planes, θ_B=the angle between the electron beam and the crystal plane, h=planck's constant and c=the speed of light.

2. PXR Intensity

This qualitative description of PXR demonstrates that PXR gives the same reflections as those formed when an X-ray beam is diffracted by the crystal [Ref. 7]. In the following discussion we sketch the treatment of Reference 7 using natural units with $\hbar$=c=1. PXR as well as X-ray diffraction can be treated two ways: 1) as dynamic theory and 2) as kinematic theory. The first case is realized in ideal crystals while kinematic theory is applicable to real crystals which consist of thin mosaic blocks turned relative to each other at the angle $\delta > m/E$. Kinematic diffraction is more convenient for experimental observation of PXR and can be most easily analyzed since the angular and spectral distributions of PXR are simplified and have a universal form for different crystals. If one takes into account the refraction of photons and the multiple scattering of electrons in the crystal then the spectral and angular distributions of emitted photons is given by [Refs. 7,8]:

$$\frac{\partial^2 N}{\partial \boldsymbol{n}_\perp \partial\omega}=\frac{e^2}{2\pi}\omega L_a|g_\tau|^2\frac{|\boldsymbol{\kappa}_B\times(\omega\boldsymbol{v}+\boldsymbol{\tau})|^2}{\left[(\boldsymbol{\kappa}_\perp-\boldsymbol{\tau}_\perp)^2+\frac{\omega^2}{v^2}(1-v^2)\right]^2}\left[1-e^{-\frac{L}{L_a}}\right]\delta(q) \tag{6}$$

$$q=\frac{\omega}{v}-\sqrt{\omega^2-\kappa_\perp^2}+\tau_z-\frac{\omega}{2}(\mathrm{Re}g_0-\theta_s^2) \tag{7}$$

$$\theta_s=\frac{E_s}{E}\sqrt{\frac{L}{L_R}} \tag{8}$$

from the general formula (18) in Reference 6. Here g_τ, g_0 are the Fourier components of the crystal dielectric constant; θ_s is the angle of multiple scattering; $E_s \simeq 21$ MeV from

Reference 7, and L_R is the radiation length. Equations (6-8) are written in the coordinate system with the z-axis directed along the particle velocity $\boldsymbol{v}$, $\boldsymbol{\kappa}_\perp = \omega \mathbf{n}_\perp$; and $L_a = (\omega \mathrm{Im} g_0)^{-1}$ is the absorption length of the crystal for X-rays of angular frequency ω, L is the thickness of the crystal. [Ref. 7] Analysis of Equations (6-8) shows that PXR consists of a series of peaks which coincide with the directions of diffractions of real photons with frequency ω_B which penetrate into the crystal at angle θ_B relative to the crystallographic planes defined by the reciprocal lattice vector $\boldsymbol{\tau}$. The distribution of PXR depends upon the crystal structure and on the angle between the particle and the crystallographic planes.

The angular distribution of PXR can be determined by integrating Equation (6) over ω. [Ref. 7] The result is

$$\frac{\partial^2 N}{\partial\theta_x \partial\theta_y} = \sum_{n=0}^{\infty} \frac{e^2}{4\pi} \omega_B^{(n)} L_a \left[1 - e^{-\frac{L}{L_a}}\right] \frac{\left|g_\tau(\omega_B^{(n)})\right|^2}{\sin^2\theta_B} \cdot \frac{\left[\theta_x^2 \cos^2 2\theta_B + \theta_y^2\right]}{\left[\theta_x^2 + \theta_y^2 + \theta_{ph}^2\right]^2}; \tag{9}$$

$$\theta_{x,y} = \frac{(\kappa - \kappa_B)_{x,y}}{\omega_B}; \qquad \omega_B^{(n)} = \frac{\pi n}{d \sin\theta_B}; \tag{10}$$

$$\theta_{ph}^2 = \frac{m^2}{E^2} + \theta_s^2 - \mathrm{Re}\, g_0 \tag{11}$$

where d is the distance between the crystallographic planes corresponding to the vector $\boldsymbol{\tau}$, and θ_{ph} is the angular spread of the reflection. Equations (9-11) can be put into a dimensionless form by means of the normalized amplitude $J \equiv N/N_0$ and angles $x,y = \theta_{x,y}/\theta_{ph}$:

$$\frac{\partial^2 N}{\partial x \partial y} = N_0 J(x,y); \qquad J(x,y) = \frac{x^2 \cos^2 2\theta_B + y^2}{(x^2 + y^2 + 1)^2}; \tag{12}$$

$$N_0=\sum_{n=1}^{\infty}\frac{e^2}{4\pi}\omega_B^{(n)}L_a\left[1-e^{-\frac{L}{L_a}}\right]\frac{\left|g_\tau(\omega_B^{(n)})\right|^2}{\sin^2\theta_B}. \tag{13}$$

The frequency distribution of PXR can be obtained by integrating Equation (6) over $\mathbf{n}_\perp$ [Ref. 7],

$$\frac{\partial N}{\partial u}=N_1 J_1(u); \qquad J_1(u)=\frac{1+u^2(1+\cos^2 2\theta_B)}{\left[1+u^2\right]^{\frac{3}{2}}} \tag{14}$$

where

$$N_1=\frac{\pi}{2}N_0; \qquad u=\frac{\sin\theta_B}{\cos\theta_B}\frac{(\omega-\omega_B)}{\omega_B\theta_{ph}}. \tag{15}$$

The total number of photons recorded by a detector of angular size θ_D about θ_B is defined by the following expression [Ref. 7],

$$\begin{aligned} N_D&=\pi N_0(1+\cos^2 2\theta_B)\int_0^{\rho_D}\frac{\rho^3 d\rho}{(\rho^2+1)^2} \\ &=N_1(1+\cos^2 2\theta_B)\left(\ln\frac{\theta_D^2+\theta_{ph}^2}{\theta_{ph}^2}-\frac{\theta_D^2}{\theta_D^2+\theta_{ph}^2}\right) \end{aligned} \tag{16}$$

where

$$\rho_D=\frac{\theta_D}{\theta_{ph}}. \tag{17}$$

References 6 and 7 were used extensively to develop the preceding discussion.

B. PEAK RATIOS

The absolute amount of PXR generated by a crystal can be calculated by using Equation (16). This calculation is complex and does not provide results that can easily be compared to experimental data. The PXR theory can be compared to the experimental results by calculating ratios between the peaks in the PXR spectrum. This is done by

comparing the $n = 2,3,...$ peaks (from the summation in Equation (13)) to the $n = 1$ peak. Substituting Equations (13) and (15) into Equation (16), dividing peak n by peak 1 and canceling factors yields

$$\frac{N_{d_n}}{N_{d_1}} \propto \frac{N_{0_n}}{N_{0_1}} = \frac{\omega_b^{(n)}}{\omega_b^{(1)}} \frac{L_{a_n}}{L_{a_1}} \frac{\left[1 - e^{\frac{-L}{L_{a_n}}}\right]}{\left[1 - e^{\frac{-L}{L_{a_1}}}\right]} \frac{|\, g_\tau\left(\omega_b^{(n)}\right)|^2}{|\, g_\tau\left(\omega_b^{(1)}\right)|^2} \tag{18}$$

where L is the crystal thickness and L_a is the x-ray absorption length,

$$|g_\tau| = \left| \frac{4 r_e \lambda^2}{\pi V} f_1 \left(\frac{\sin\theta_B}{\lambda} \right) \right|, \tag{19}$$

where f_1 is the x-ray scattering factor, V is the crystal unit cell volume and r_e is the classical electron radius [Refs. 6,7,9], and with

$$\lambda = \frac{2d\sin\theta_B}{n}, \qquad \omega_b^{(n)} = \frac{\pi n}{d\sin\theta_B}, \tag{20}$$

substituted into Equation (18) yields,

$$\frac{N_{0_n}}{N_{0_1}} = \frac{1}{n^3} \frac{L_{a_n}}{L_{a_1}} \frac{\left[1 - e^{\frac{-L}{L_{a_n}}}\right]}{\left[1 - e^{\frac{-L}{L_{a_1}}}\right]}. \tag{21}$$

III. PXR EXPERIMENT

Several PXR measurements were made using a 1.75 mm thick Silicon monochromator mounted on an Aluminum holder and a 1 mm thick Lithium Fluoride monochromator mounted on a similar Aluminum holder. The data from the Silicon crystal was compared to previous data taken from 20 μm, 44 μm, and 320 μm Silicon crystals [Ref. 5]. This data was reanalyzed using the procedures described later.

A. ACCELERATOR OPERATION

The Naval Postgraduate School (NPS) Electron Linear Accelerator (LINAC), shown in Figure 2, was used to conduct these experiments. The LINAC has a rated beam energy of 100 MeV but the actual beam energy varied with each experiment. The beam energy was 96 MeV for these experiments except for one Lithium Fluoride run which was conducted at 62 MeV.

The LINAC is pulsed at 60 Hz with a macro structure length of 1 μsec. The SiLi detector used has a nominal time resolution of 12 μsec determined by the pre-amplifier. To prevent double counting, (two photons entering the detector at nearly the same time being counted as one photon of higher energy) the LINAC was run using dark current only for data runs to limit the number of photons detected over the energy range of the detector to one every three to five machine pulses. Dark current is achieved by turning the gun grid voltage off and accelerating only stray electrons. This yields a current estimated to be less than 2 x 10^{-13} Amperes. It is important to eliminate double counting

during PXR experiments since two photons from the n=1 reflection added together have the same energy as one photon from the n=2 reflection. Double counting will cause the ratios between the observed peaks to be wrong. Maintaining a constant dark current was difficult and required constant operator attention [Ref. 10].

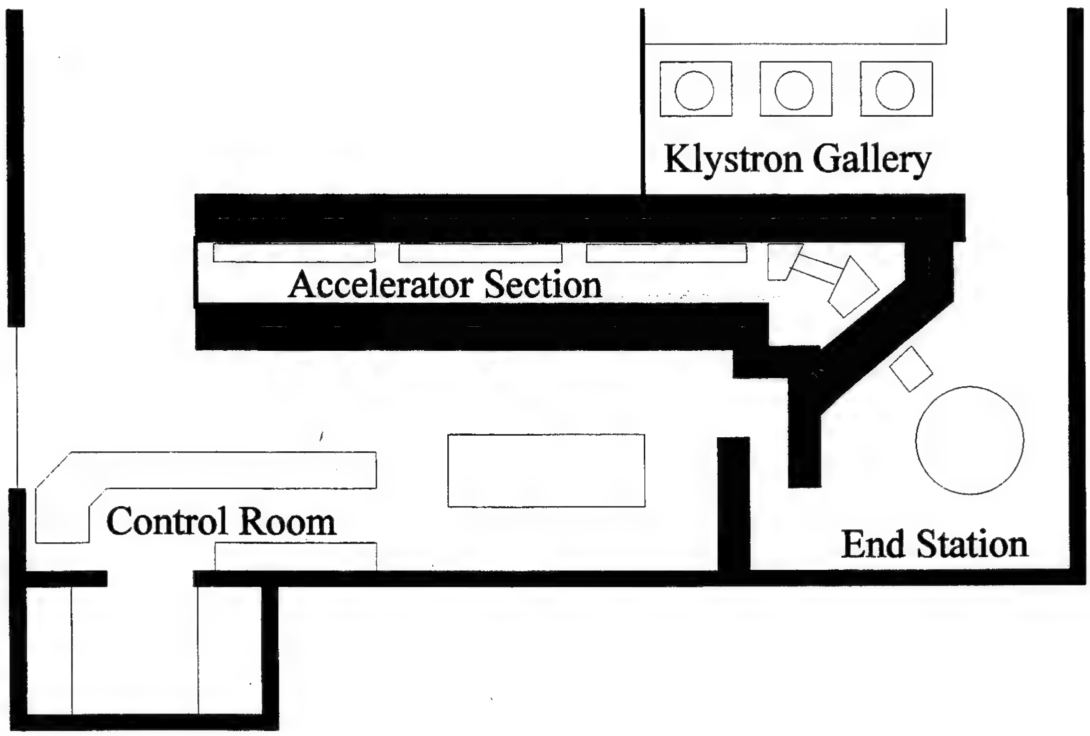


Figure 2. Naval Postgraduate School 100 MeV Linear Accelerator.

B. BEAM ALIGNMENT

Beam alignment during PXR experiments is critical since the energy of the PXR observed depends upon the angle that the beam enters the crystal. To align the beam the LINAC was operated in the normal mode and the beam was steered to pass through a pinhole in a phosphorescent screen located at the center of the experimental chamber mounted on the ladder assembly and to strike the middle of a phosphorescent screen

located at the beam exit port as shown in Figure 3. These screens were observed by television cameras monitored in the control room.

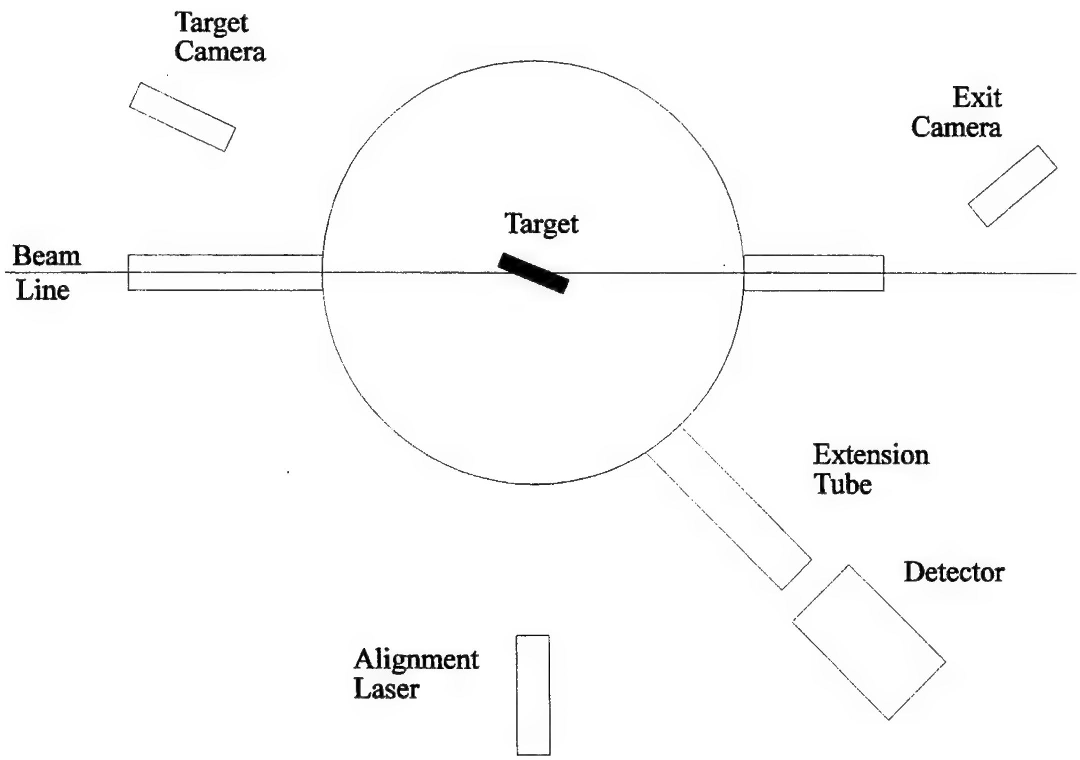


Figure 3. PXR experiment end station setup.

The target monochromators were mounted on the upper portion of the ladder assembly shown in Figure 4. The ladder assembly can rotate through 360 degrees controlled by a computer controlled motor. The upper portion of the ladder assembly can be tilted forward and backwards to ensure that the crystal is perpendicular to the beam. This tilt is also controlled by a computer controlled motor. In order to ensure that the crystal is perpendicular to the beam an alignment laser is bounced off of the crystal (or for crystals that do not reflect, a front silvered mirror was mounted adjacent

to the crystal) and the position of the reflection is observed by a television camera monitored in the control room. The motors controlling ladder movement are adjusted until proper alignment is achieved. This can be a tricky process since there is some backlash in the motor couplings and gears moving the ladder.

The ladder assembly consists of two sections. The fixed lower section which held the phosphorescent alignment screen and the tri-foil calibration stack. There is also an open position and room for other calibration foils. The upper tilting section of the ladder holds an aluminum plate which has cutouts for mounting up to three different target monochromators and an alignment mirror.

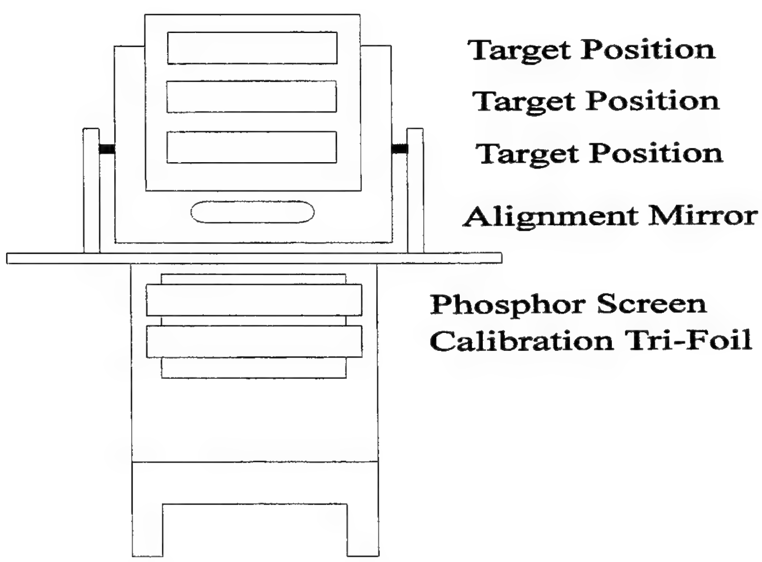


Figure 4. Target and calibration foil ladder assembly.

C. DETECTOR AND ELECTRONICS

The detector used for these PXR experiments was a Canberra Model SL200250 series 7300 Lithium drifted Silicon (SiLi) detector. The detector had an active area of 200 mm^2 and was 5 mm thick. The detector was mounted 5 mm behind a 0.05 mm Beryllium window and maintained under a vacuum and cooled in a cryostat to liquid nitrogen temperatures. [Ref. 11]

The detector was placed at the end of a 40.3 cm extension tube placed on the experimental chamber. The extension tube had a 0.025 mm kapton window. There was a 1 cm air gap between the extension tube window and the detector window. The detector high voltage power supply and ORTEC 571 preamplifier were located in the LINAC end station while the amplifier, counters and pulse height analyzer were located in the control room. The electronic signal connections are diagrammed in Figure 5. Due to the proximity of the end station to the klystron gallery shielding the detector and end station electronics was very important. Shielding included wrapping the electronics enclosure and detector with copper mesh screening that was then grounded. Proper grounding and trial and error shielding were important to reduce klystron noise.

The output of the preamplifier was then sent to the control room where it was amplified by a TENNELEC TC 244 amplifier then sent to a TENNELEC TC 304 linear gate. The gate was triggered by a Stanford Research System model DG 535 four channel digital delay/pulse generator. The output of the gate was sent to a digital counter, a two channel oscilloscope and a NUCLEUS Personal Computer Analyzer

(PCA-II) card installed in an IBM compatible personal computer. The PCA-II software was operated in the Pulse Height Analyzer (PHA) mode. [Ref. 12]

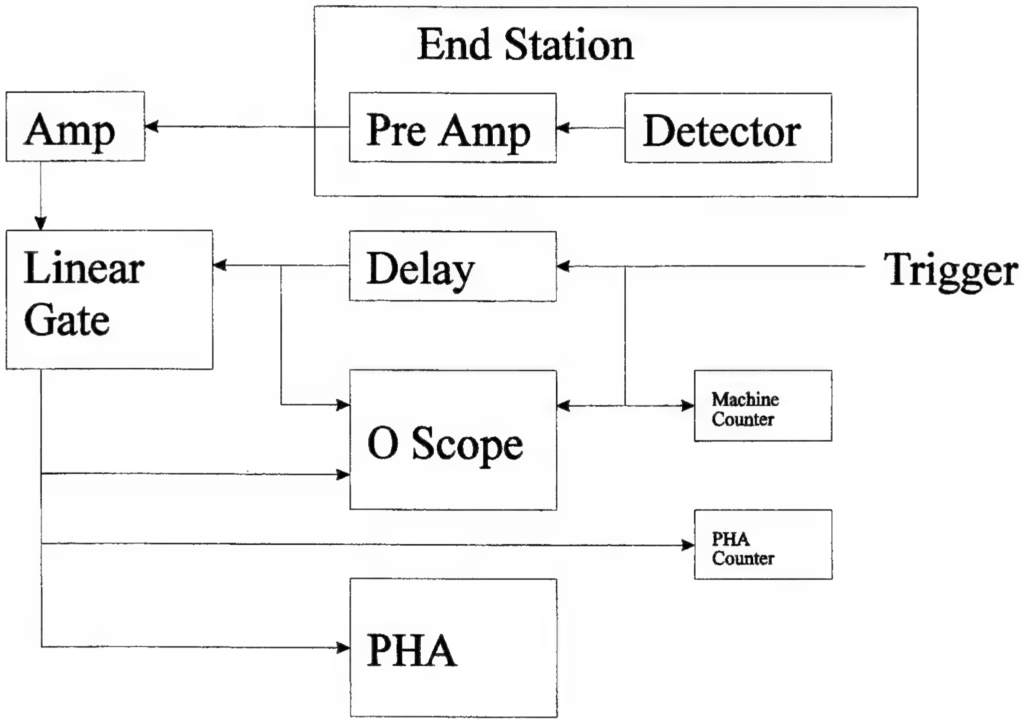


Figure 5. PXR Electronics Setup.

The pulse generator was triggered by the T_0, LINAC pulse start time signal. This signal was also used to trigger the oscilloscope and was sent to a digital counter to count machine pulses. The ratio between the machine pulse counter and the PHA counter was observed by the operators and used to control the dark current. To prevent double counting this ration was kept between 1:3 and 1:6.

The pulse generator delay time was adjusted so the start of the gate coincides with the arrival of the beam pulse at the target. The signal to the PHA and the pulse generator output were observed on the oscilloscope and the width of the gate and the

delay time were adjusted so the detector pulse would be recorded by the PHA but any stray pulses and klystron noise would not be recorded. The optimum delay time, determined by trial and error, was 25 μsec with a width of 46 μsec.

IV. DATA COLLECTION

A. ENERGY CALIBRATION

Prior to conducting any PXR experiment the detector and electronics setup required an energy calibration. The calibration was determined by observing the x-ray fluorescence lines from a sandwich of tin, titanium and yttrium foils, shown in Figure 6, inserted into the LINAC electron beam path [Refs. 10,13]. Data collection time for

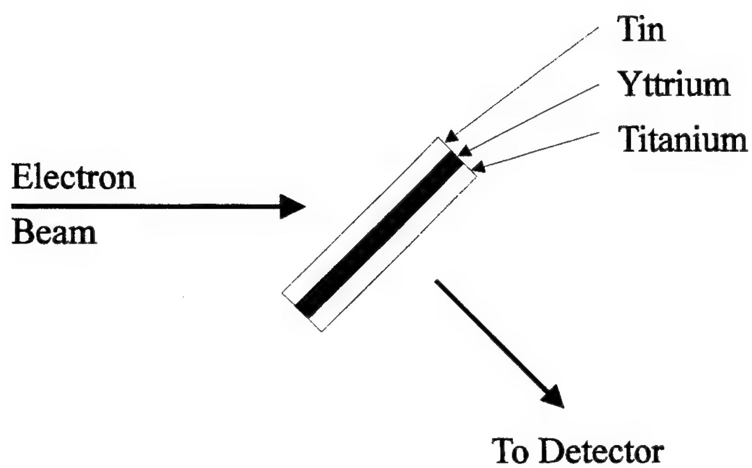


Figure 6. Tri-Foil used to determine energy calibration by observing x-ray fluorescence lines.

an energy calibration run varied, the calibration run data was collected until distinct x-ray fluorescence peaks were observed on the PHA. A typical calibration run output is shown in Figure 7. The calibration spectrum was then saved to disk for later analysis. A rough energy calibration was performed by estimating the peak channel numbers and performing a linear regression fit on a handheld calculator using x-ray fluorescence line data [Ref. 14]. This was done to ensure that the data being collected was at roughly the

predicted energy. During long data collection runs a second energy calibration run was conducted as a precaution after completion of data collection to take into account any drift in detector response during data collection. In all cases observed drift was negligible.

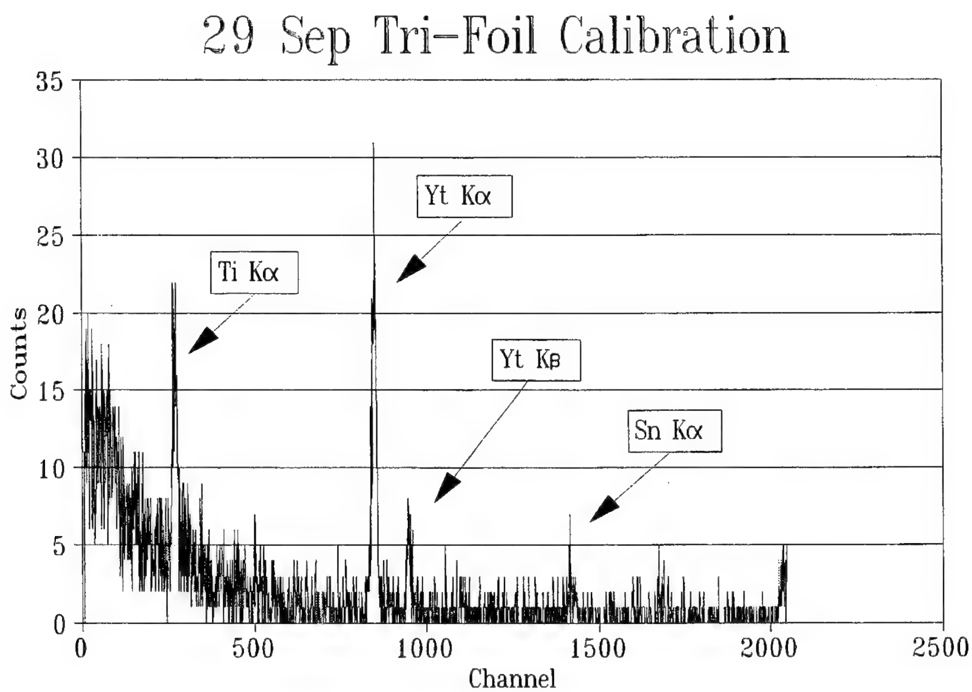


Figure 7. Typical x-ray fluorescence lines observed during an energy calibration run using the Titanium, Yttrium, and Tin tri-foil.

B. PXR DATA RUNS

After completion of the calibration run the ladder was moved down and rotated to place the crystal in the electron beam to collect PXR data. The counting rate during PXR data collection was reduced to the 1:3 to 1:6 ratio to prevent double counting. Data

collection was done with the crystal plane at an angle of 22.5 degrees with respect to the electron beam. Data collection time varied from several to over twelve hours in order to observe as many peaks in the spectrum as possible. A typical PXR data collection run output is shown in Figure 8. Long data collection times enabled high order peaks to emerge above the background signal. The LiF runs were not as long as the Si runs since the object of the LiF runs was to take some exploratory data on PXR generated by the crystal since PXR from this target had never been observed. During the 29 September run a thin tin foil was placed behind the 1.75 mm silicon crystal and its 2 mm thick aluminum holder in an attempt to observe the tin x-ray fluorescence line during the data collection run to provide an energy reference as done during previous carbon mosaic crystal experiments [Ref. 5]. The tin x-ray fluorescence peak was not observed due to attenuation of the x-rays by the aluminum holder and the silicon crystal. A comparison of calculated x-ray attenuation factors of the silicon crystal in the aluminum holder, as in this experiment, and the 1.3 mm thick carbon mosaic crystal used in Reference 5, is shown in Figure 9. During all runs data was saved to disk every hour to aid in analysis and if necessary to subtract out times when the data may not have been ideal due to double counting or klystron noise.

A summary of PXR data collection runs is shown in Table 1. The data collection run on 22 October 1992 was cut short when a high voltage power supply failed. The data collection runs in December were done using dark current only without the main beam for initial set up and focusing since the electron gun had failed. This meant that the beam focusing had to be estimated which was done by observing the PXR spectrum

at various angles and choosing the angle where the count rate was the highest. The beam angle error for these runs is estimated at ± 1 degree.

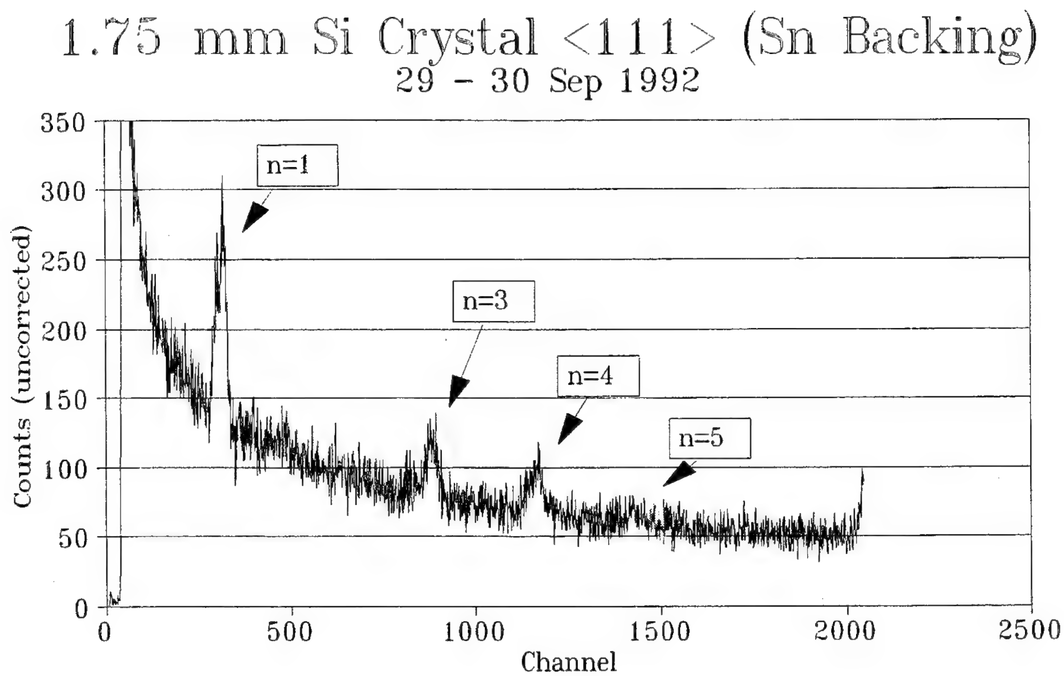


Figure 8. Typical PXR raw data spectrum of a 1.75 mm Silicon Crystal showing four peaks, $E_B=100$ MeV, $\theta_B=22.5°$. This run included a tin backing foil, however the tin line was not observed.

Crystal	Linac Energy	Date	Run Time
Si (111)	96 MeV	25 Sep 92	5½ Hours
Si (111)	96 MeV	29 Sep 92	12 Hours
Si (111)	91 MeV	2 Dec 92	3 Hours
LiF (220)	95 MeV	22 Oct 92	38 Min
LiF (220)	92 MeV	1 Dec 92	2¼ Hours
LiF (220)	62 MeV	3 Dec 92	2¾ Hours

Table 1. Summary of PXR Data Collection Runs.

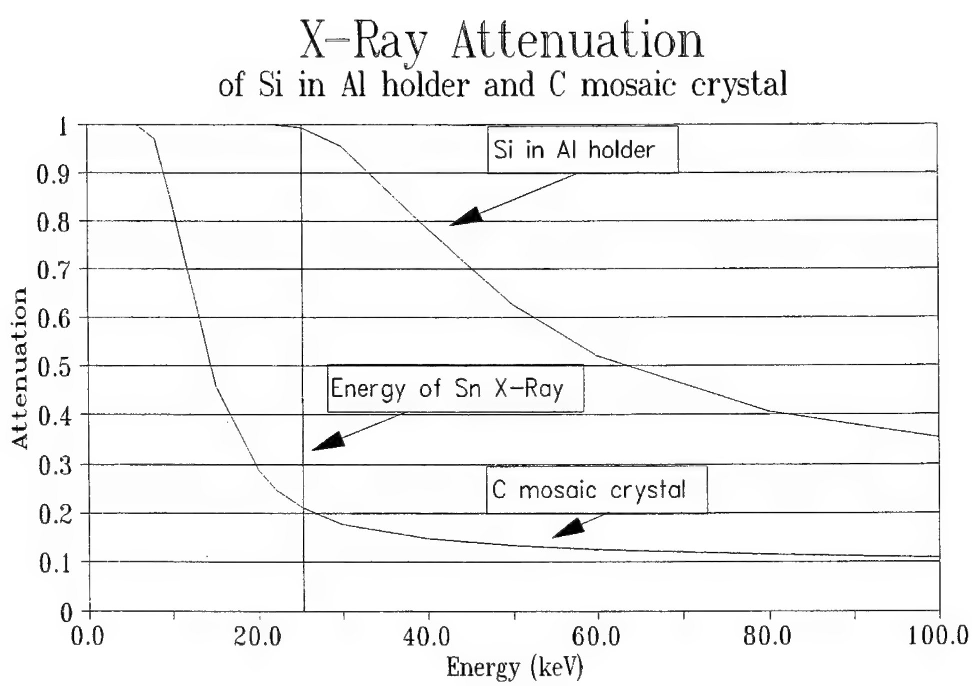


Figure 9. Comparison of x-ray attenuation factors for the Silicon Crystal in an Aluminum holder and a Carbon mosaic crystal.

V. DATA ANALYSIS

A. ENERGY CALIBRATION

The first step of data analysis was to use the energy calibration data and convert channel number to energy. The raw energy calibration spectrum (shown in Figure 7) was analyzed to find the center channel for each observed peak. This was done using Peakfit, a program from Jandel Scientific [Ref. 15]. A typical Peakfit energy calibration run output is shown in Figure 10.

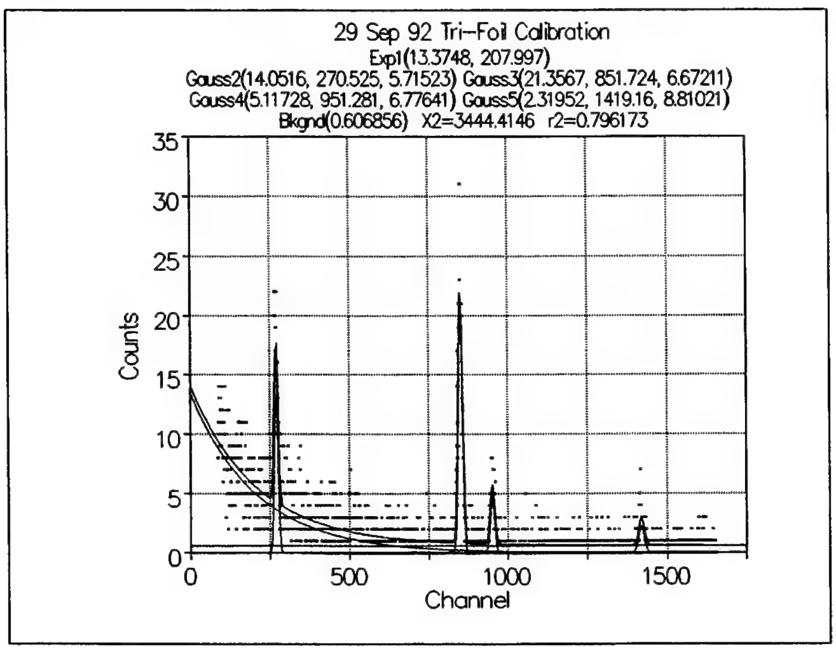


Figure 10. A Peakfit graphic output showing data, parameters of curves fit and graphic output of curves and background.

Peakfit uses the Marquardt-Levenberg algorithm [Ref. 15] to find the minimum value of the sum of the squared deviations between the data and the projected curve

functions. The observed peaks were best fit using Gaussian functions while the background was a combination of an exponential and a linear function. Peakfit also provides a detailed numerical output. An edited version of this output is shown below. Sections of the output of particular interest are highlighted as shown. The Curve-Fit Std Error and r^2 give a measurement of the exactness of the fit of the data compared to other fit attempts. The Standard Error is

$$\text{Std E} = \left[\frac{\chi^2}{\nu} \right]^{1/2}, \tag{22}$$

where ν = the number of degrees of freedom and χ^2 = the sum of the square of the residuals,

$$\chi^2 = \sum_{i=1}^{n} (y_i - Y_i)^2, \tag{23}$$

where y_i = y value of the curvefit at ith data point, and Y_i = y value of ith data point. The coefficient of determination, r^2 is

$$r^2 = 1.0 - \frac{\sum_{i=1}^{n} (y_i - Y_i)}{\sum_{i=1}^{n} (y_i - \bar{y})}. \tag{24}$$

The Curve-Fit Coefficients section lists the final values of the coefficients used to determine all of the curves in the data set. The Measured Values section gives data for all of the curves in the set. The peak center (PkCtr) and the Area are the data values which are used in later analysis. The Peak# section gives detailed information about each

peak including the standard error and confidence limit range for each parameter. The last section consists of an analysis of variance for the curve-fit. [Ref. 15]

```
                    PeakFit Numerical Summary

Description:   29 Sep 92 Tri-Foil Calibration
X-Y Table Size: 2048   Active Points: 1567
X Variable: Channel
Y Variable: Counts
File Source: CAL929X3.PRN

Curve-Fit Std Error= 1.4897447     r2= 0.796173001

Background Coefficients [y=a+bx+cx^2+dx^3]
Background          a          b          c          d
     Order=0    0.6068557

Curve-Fit Coefficients
Peak#   Type        Ampl        Ctr         Wid1        Wid2
  1  Exp          13.374803  207.99687
  2  Gaussian     14.051629  270.52525   5.7152349
  3  Gaussian     21.356656  851.7238    6.6721124
  4  Gaussian     5.1172806  951.28139   6.7764128
  5  Gaussian     2.3195225  1419.1646   8.8102087

Measured Values
Peak#   Type        PkAmpl      PkCtr       Wid@HM      Area        %Area
  1  Exp              0           0           0           0           0
  2  Gaussian     14.051629  270.52525   13.458337  201.30322  28.89673
  3  Gaussian     21.356656  851.7238    15.711563  357.18045  51.272637
  4  Gaussian     5.1172806  951.28139   15.957158  86.921956  12.477497
  5  Gaussian     2.3195225  1419.1646   20.746413  51.224134  7.353136
     Total                                          696.62975  100

Peak# 2  Gaussian
  PkAmpl         PkCtr          Wid@HM         Area
  14.05162926    270.5252467    13.45833709    201.3032188
  XL @HM         XR @HM         Ctr-XL@HM      Ctr-XR@HM
  263.7960806    277.2544177    6.729166082    6.729171013
 Parm  Value          Std Error     t-value       95% Confidence Limits
 Ampl  14.05162926   0.576342916   24.38067489   12.92367189   15.17958663
  Ctr  270.5252467   0.269251155   1004.731983   269.9982968   271.0521965
 Wid1  5.715234918   0.273520137   20.89511577   5.179930249   6.250539587

Total Peaks= 5    Coefficient Count= 15    Fitted Count=15
Std Error for Curve= 1.489744704      r2= 0.7961730012
Source    Sum of Squares     DF       Mean Square          F
Regr      13454.301          14       961.02153            433.021
Error     3444.4146          1552     2.2193393
Total     16898.716          1566
```

The peak centers, as determined by Peakfit, are matched up with the x-ray fluorescence line energy from Reference 14 and a linear regression fit is performed using

the spreadsheet Quattro Pro [Ref. 16]. Typical linear regression calculations used to determine energy are shown in Table 2.

Element	X-Ray Line	Channel	Energy (keV)
Ti	Kα	270.5	4.507
Yt	Kα	851.7	14.9
Yt	Kβ	951.3	16.9
Sn	Kα	1419.2	25.2

Constant	X Coefficient
-0.48599	0.017963

Table 2. Typical Linear Regression Calculations.

The linear regression fit is used to convert channel number to energy in a spreadsheet containing the PHA data using Equation 25,

$$E = a + bX, \tag{25}$$

where E is the Energy, a is the linear regression constant, b is the linear regression x coefficient and X is the Channel Number. Detailed energy calibration data, Peakfit curves, Peakfit data summaries and linear regression calculations are contained in Appendix A.

B. PXR DATA ANALYSIS

Raw PXR data was collected by the PHA and stored on disk. Some of this data was collected using the 8K channel option and other data was collected using the 2K channel option [Ref. 12]. Two thousand channels were enough to provide the energy

resolution required and made the data files easier to manipulate using the spreadsheet. The energy resolution is 0.018 keV per channel in the typical 2K channel option and 0.0044 keV per channel for the 8K channel option. A Q-basic program was written to convert the 8K files to 2K. This program is listed in Appendix B.

The PHA data files were imported into the Quattro Pro spreadsheet and then the results of the energy calibration files were used to convert channel number to energy. This then yields the uncorrected PXR spectrum, a typical example is shown in Figure 11.

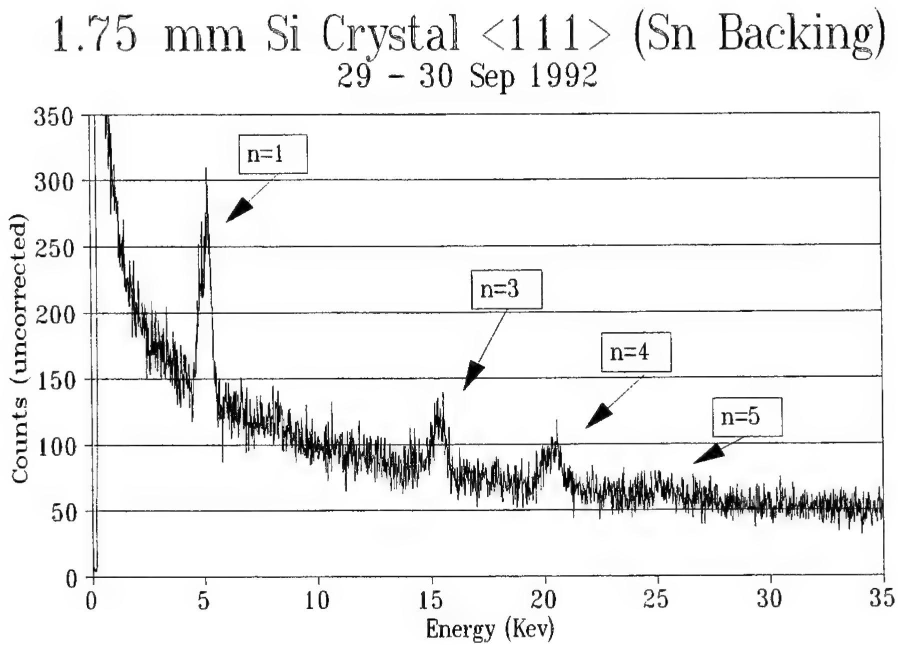


Figure 11. Typical uncorrected PXR spectrum after energy calibration of a 1.75 mm Silicon Crystal, E_B=100 MeV, θ_B=22.5°. This is the raw data shown in Figure 8 calibrated using the energy calibration curve shown in Figure 10.

The PXR uncorrected line intensities are determined by using Peakfit to analyze the uncorrected data. Peakfit generates a graphical representation of the data, a typical

example is shown in Figure 12, as well as a detailed numerical output as previously described.

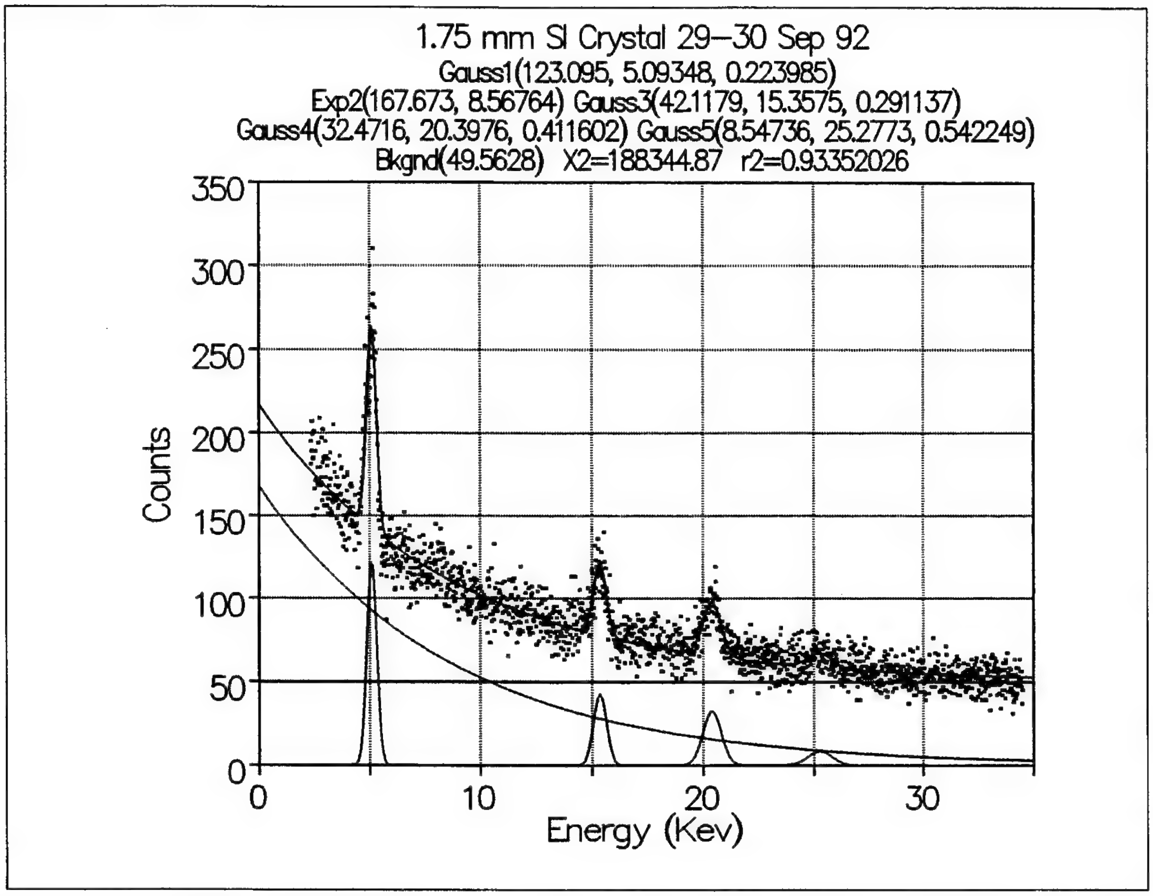


Figure 12. Typical uncorrected data Peakfit output. This is the peakfit data output for the uncorrected 1.75 mm Silicon Crystal data shown in Figure 11.

Previously collected data from thin crystals [Ref. 5] were also analyzed using these procedures and will be presented in Chapter VI. The uncorrected PXR spectrums as well as the Peakfit numerical summaries are contained in Appendix C.

The spectrums collected must be corrected to show the true PXR spectrum since the detected photons have had to travel through the kapton window at the end of the experimental chamber extension tube, the air gap between the extension tube and the

detector and the beryllium window at the end of the detector. The detector response must also be considered since every photon that enters the detector does not result in a count out.

Attenuation of photons traveling through a material is described by

$$I=I_0 e^{-\mu\rho t} \tag{26}$$

where μ is the photon attenuation coefficient, ρ is the density of the material and t is the thickness of the material. The total attenuation correction is given by

$$I_0=\frac{I_D}{e^{-\mu_{\mathrm{kap}}\rho_{\mathrm{kap}}t_{\mathrm{kap}}-\mu_{\mathrm{air}}\rho_{\mathrm{air}}t_{\mathrm{air}}-\mu_{\mathrm{Be}}\rho_{\mathrm{Be}}t_{\mathrm{Be}}}}. \tag{27}$$

the attenuation coefficient μ depends upon the energy of the photon. A computer program, XCOM, was used to calculate attenuation coefficients [Ref. 17]. To correct the complete graph, XCOM's feature that allows calculation for an input energy grid was used to calculate a separate correction factor for each channel of data in the spectrum files. XCOM would only accept an energy grid of less than 500 points and since the data files are over 2000 channels various QBasic programs and command files were written to speed up this procedure, as detailed in Appendix D.

The attenuation coefficients were imported into the spreadsheet data files and then Equation 24 was applied to determine revised counts for each energy channel in the spectrum. Densities and thicknesses used are listed in Table 3.

The next correction to apply is the correction for detector efficiency. This was calculated using the attenuation coefficient for Si, as calculated by XCOM, and the

	Kapton	Air	Be
Composition (by mass)	$C_{22}O_5N_2H_{10}$	N_2 75.75% O_2 23.00% Ar 1.20% CO_2 0.05%	Be
ρ (gm/cm^3)	1.42	1.225×10^{-3}	1.85
t (cm)	0.0025	1	0.005

Table 3. PXR Attenuation Materials.

equation below,

$$\text{DetectorEff} = 1 - \text{DetectorAtten}. \tag{28}$$

This data was then plotted, as shown in Figure 13 and compared to the published detector efficiency curves shown in Figure 14. [Refs. 11,18] The detector efficiency curves were compared but did not match. Figures 13 and 14 are superimposed in Figure 15 to demonstrate this comparison. It appeared that the calculated efficiency for a 3 mm detector matched the given efficiency for the 5 mm detector that was used so the 3 mm calculations were added to the spreadsheet data to determine the corrected counts in the spectrum files. A typical corrected PXR spectrum is shown in Figure 16.

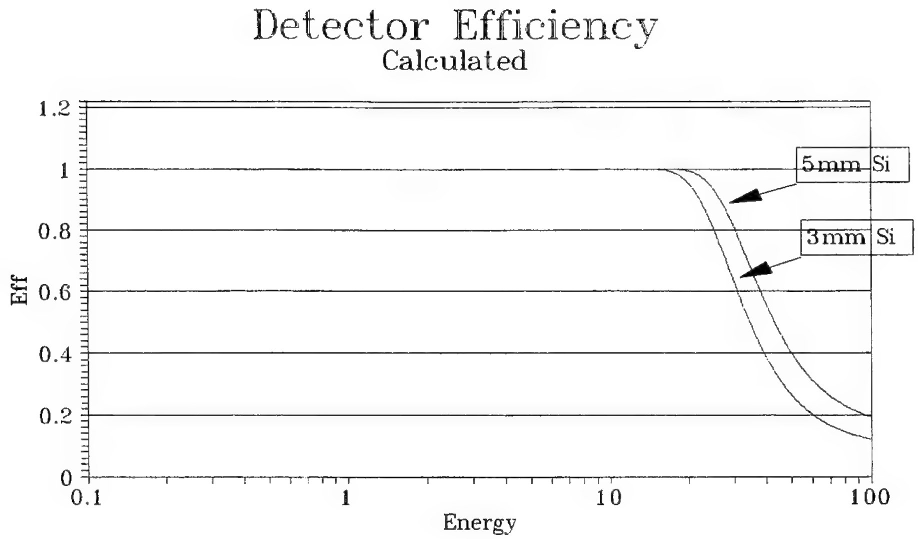


Figure 13. Silicon detector calculated efficiency curve using XCOM.

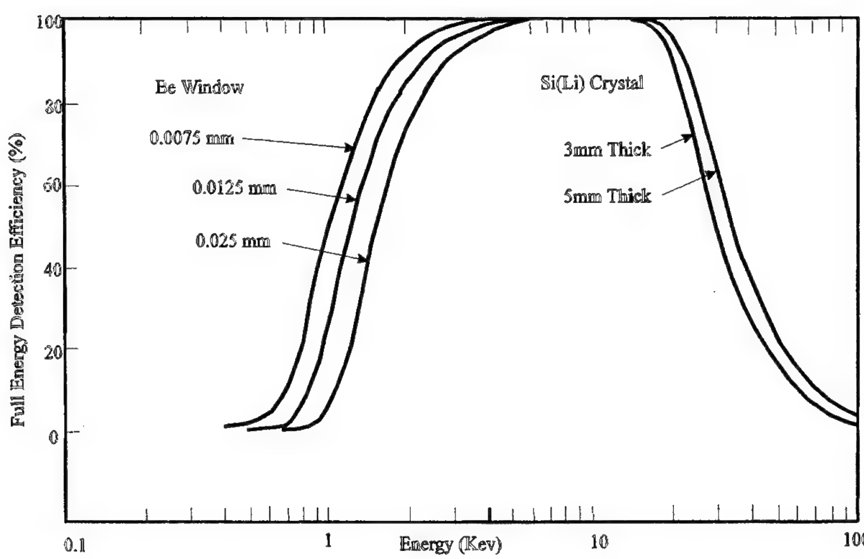


Figure 14. Silicon detector published efficiency curve. [From Refs. 11,18]

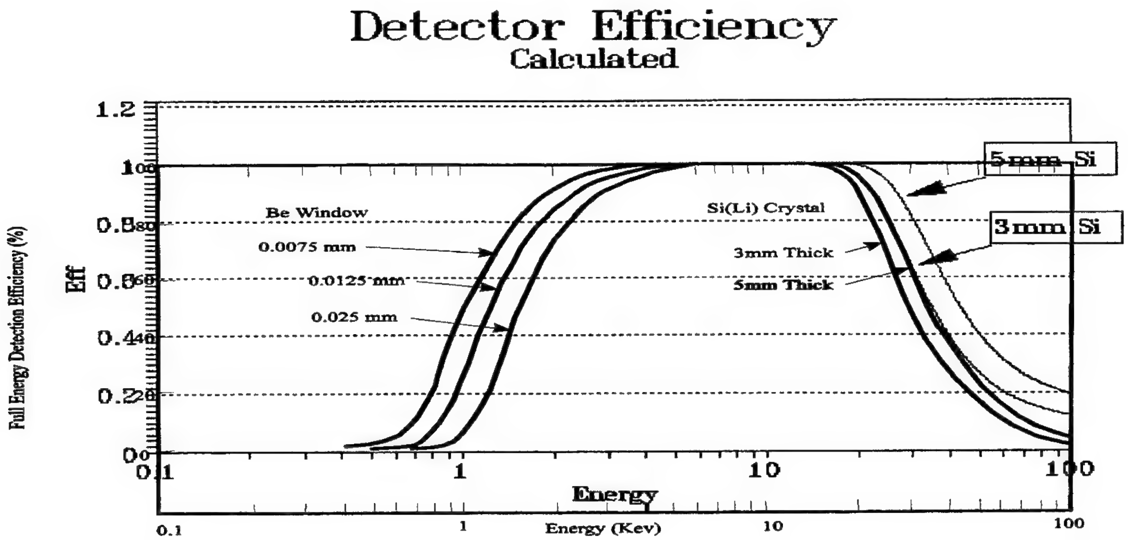


Figure 15. Superimposed calculated and published detector efficiency curves.

After correction for attenuation and detector efficiency the PXR spectrums were analyzed using Peakfit to determine the peak centers and intensities. The corrected spectrums and Peakfit numerical summaries are contained in Appendix E.

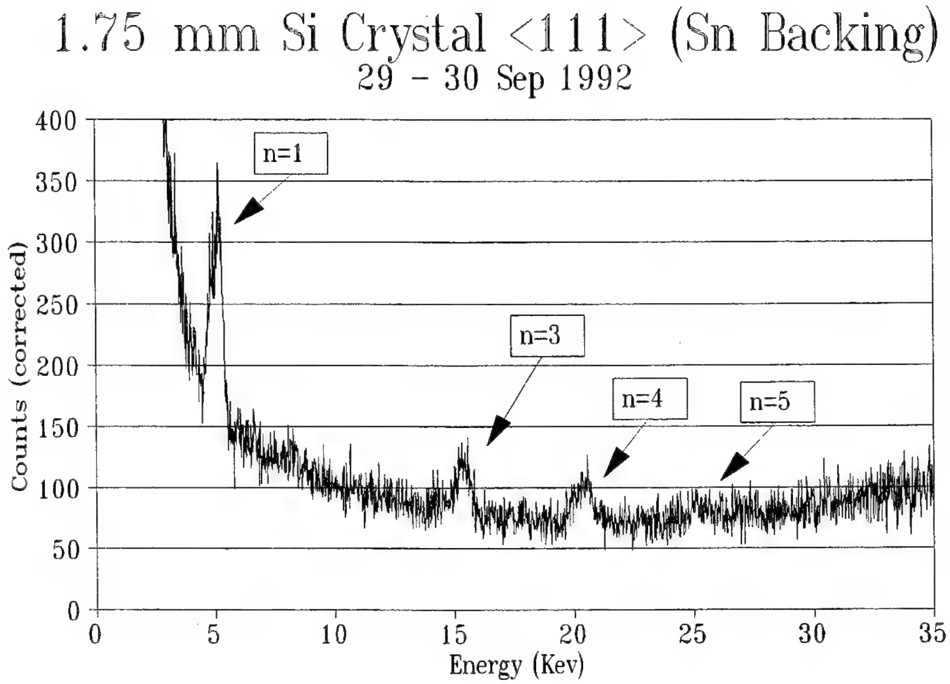


Figure 16. Typical corrected PXR spectrum of a 1.75 mm Silicon Crystal, $E_B=100$ MeV, $\theta_B=22.5°$. This is the same data as Figure 11, after attenuation corrections have been completed.

VI. SILICON CRYSTAL RESULTS

A. ENERGY PEAKS

1. 1.75 mm Thick Crystal

The energy of observed PXR peaks is given by Equation 5. The 1.75 mm thick silicon monochromator has a crystal plane spacing of 0.313 nm in the <111> orientation [Ref. 19]. For all experiments, θ_B is 22.5 degrees. The theoretical and observed peak energies are compared in Table 4. The n=2 peak was not observed and

Peak n=	Theoretical Energy(keV)	25 Sep 92 Energy(keV)	29-30 Sep 92 Energy(keV)	2 Dec 92 Energy(keV)
1	5.18	5.14 $\pm$.09	5.09 $\pm$.20	5.43 $\pm$.25
2	10.37			
3	15.55	15.48 $\pm$.09	15.36 $\pm$.20	15.76 $\pm$.25
4	20.74	20.56 $\pm$.09	20.40 $\pm$..20	21.02 $\pm$.25
5	25.92	25.49 $\pm$.15	25.28 $\pm$.20	26.33 $\pm$.25

Table 4. 1.75 mm Thick Silicon Crystal PXR Energy Peaks.

should not be observed as it is a forbidden transition in this crystal orientation. The observed energy peaks are close to the predicted values. The uncertainties shown in the table are the larger of either the standard error of the energy calibration linear regression calculation or the standard error of the location of the peak as determined by Peakfit. The energy values observed during the 2 December run fall outside of the predicted values. Working Equation 5 in reverse yields a θ_B=22.2° for the 2 December data

collection run. This error in the actual θ_B was caused by the inability to know the exact position of the electron beam due to the failure of the electron gun which resulted in this run being conducted using dark current only. In a dark current condition the electron beam position must be estimated since the beam does not have enough current to cause the phosphor alignment screens to fluoresce brightly enough for the alignment cameras to detect. For a 1.75 mm thick silicon crystal the observed energy peaks were in good agreement with the predicted peaks.

2. Thin Crystal

Previously analyzed thin silicon crystal data [Ref. 5] was re-examined using the same data analysis programs as the thick crystals so meaningful intensity comparisons could be made. Thin crystal observed peak energies are compared to theoretical energy and the averaged observed energy for the 1.75 mm thick crystal in Table 5.

Peak n=	Theoretical Energy(keV)	1.75 mm thick Energy (keV)	320 μm thick Energy (keV)	44 μm thick Energy (keV)	20 μm thick Energy (keV)
1	5.18	5.11 $\pm$.005	5.19 $\pm$.004	4.94 $\pm$.003	5.26 $\pm$.001
2	10.37				
3	15.55	15.42 $\pm$.03	16.69 $\pm$.02	16.38 $\pm$.05	16.05 $\pm$.05
4	20.74	20.50 $\pm$.04	22.49 $\pm$.03	22.25 $\pm$.15	21.51 $\pm$.09
5	25.92	25.48 $\pm$.15	28.24 $\pm$.11	NO	NO

Table 5. 1.75 mm and Thin Silicon Crystal PXR Energy Peaks.

The energy peaks observed in the re-examined thin crystal trials did not match the theoretical values. The discrepancies exist for a number of different reasons. In the 320 μm case the ΔE between orders = 5.75 keV indicating that $\theta_B \approx 20.2°$. Similarly in the 44 μm case the ΔE = 5.87 keV indicating a $\theta_B \approx 19.8°$. In both cases n=1 peak is not

seen at the expected energy indicating there may be a problem with the calibration run. This data was taken using a titanium and copper calibration foil stack which has calibration peaks at 4.5 keV, 8.04 keV and 8.94 keV, which does not cover the whole range of data. This data also was taken with a different detector. When Peakfit was used to analyze the calibration files the titanium linewidth between the Ortec detector (thin data) and the Canberra detector (1.75 mm data) was about twice as wide indicating that the energy of the Ortec detector may drift slightly during these trials. The 20 μm data has a $\Delta E = 5.46$ keV indicating a $\theta_B \approx 21.3°$. The 20 μm n=1 peak is where it was expected indicating that the calibration run in this case was accurate. The n=2 peak was not observed since it is a forbidden transition. The variation in the position of the energy peaks seems to have been caused by the electron beam not passing through the center of the target. In the thin crystal trials the crystal was rocked until the maximum PXR was observed. This rocking, combined with beam alignment, changed the θ_B which was being observed. This different θ_B, for different runs, makes the comparison of peak energies between runs not meaningful, however the comparison of intensity ratios should not be affected since the true PXR spectrum was being observed in all cases. It should be noted that to make meaningful comparisons between peak energies of different crystal thicknesses it is vital that the beam be accurately aligned with the crystal and detector so θ_B is identical in all cases.

B. PEAK INTENSITY RATIOS

Theoretical intensity ratios were calculated using Equation 21. The absorption length, L_a was determined by using the density [Ref. 20], and the photon attenuation coefficient μ determined by XCOM [Ref. 17], using

$$L_a = \frac{1}{\mu\rho}. \tag{29}$$

The theoretical and observed intensity ratios for the 1.75 mm thick silicon crystal are compared in Table 6 and Figure 17. The uncertainties in the intensity ratios were

Peak Ratio	Theoretical Ratio	Observed 25 Sep 92	Observed 29-30 Sep 92	Observed 02 Dec 92	Average
3-1	.88	.40 ±.03	.31 ±.02	.45 ±.02	.39±.03
4-1	.71	.28 ±.03	.32 ±.02	.42 ±.03	.34±.03
5-1	.49	.13 ±.04	.13 ±.02	.11 ±.03	.12±.04
4-3	.81	.70 ±.09	1.03 ±.08	.93 ±.08	.89±.09
5-3	.55	.33 ±.09	.42 ±.06	.24 ±.06	.33±.09
5-4	.69	.46 ±.13	.41 ±.06	.26 ±.07	.38±.13

Table 6. 1.75 mm Thick Silicon PXR Peak Intensity Ratios.

determined by calculating the uncertainty in the area for each peak using data from the Peakfit numerical summary and then adding the fractional uncertainty for the peaks in question. [Ref. 21] The ratios observed during the three 1.75 mm thick silicon crystal runs are consistent with each other but do show some significant differences with the expected theoretical calculations.

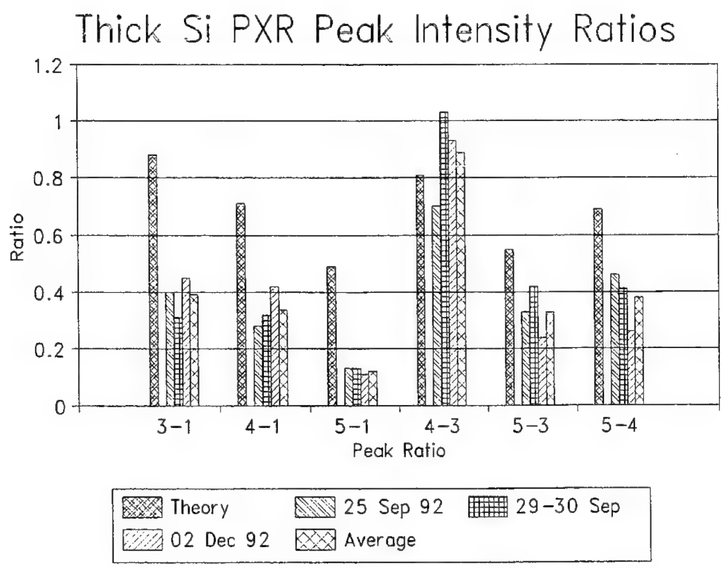


Figure 17. 1.75 mm Thick Silicon Peak Intensity Ratios.

Peak intensity ratios for the thin crystal runs also show some disparity between the expected values and the observed results. The intensity ratios are compared in the Tables 7 and 8 and Figures 18 and 19. The ratios observed here are close to the theoretical values for the thinner crystals (44 μm and 20 μm), however the observed ratios are smaller than expected for the thicker crystals (320 μm and 1.75 mm). It appears that the thicker the crystal the more the intensity ratios diverge from the current PXR theory. One factor that may be causing this divergence from theory is attenuation of the lower order PXR that is generated deep in the crystal as it travels to the surface.

Peak Ratio	1.75 mm SA		320 μm SA		44 μm SA		20 μm SA	
	Theory	Obsvd	Theory	Obsvd	Theory	Obsvd	Theory	Obsvd
3-1	.88	.39±.03	.45	.32±.01	.090	.057±.01	.059	.031±.01
4-1	.71	.32±.03	.23	.23±.01	.040	.030±.01	.025	.014±.01
5-1	.49	.12±.02	.12	.05±.01				
4-3	.81	.89±.09	.51	.71±.04	.44	.53±.15	.42	.45±.11
5-3	.55	.33±.09	.27	.16±.03				
5-4	.69	.38±.13	.52	.22±.05				

Table 7. 1.75 mm and Thin Silicon PXR Peak Intensity Ratios.

Peak Ratio	1.75 mm SA Obsvd/Theory	320 μm SA Obsvd/Theory	44 μm SA Obsvd/Theory	20 μm SA Obsvd/Theory
3-1	.44	.71	.63	.53
4-1	.45	1.00	.75	.56
5-1	.24	.42		
4-3	1.01	1.39	1.20	1.07
5-3	.60	.59		
5-4	.55	.42		

Table 8. Ratios of observed PXR ratios compared to theoretical PXR ratios.

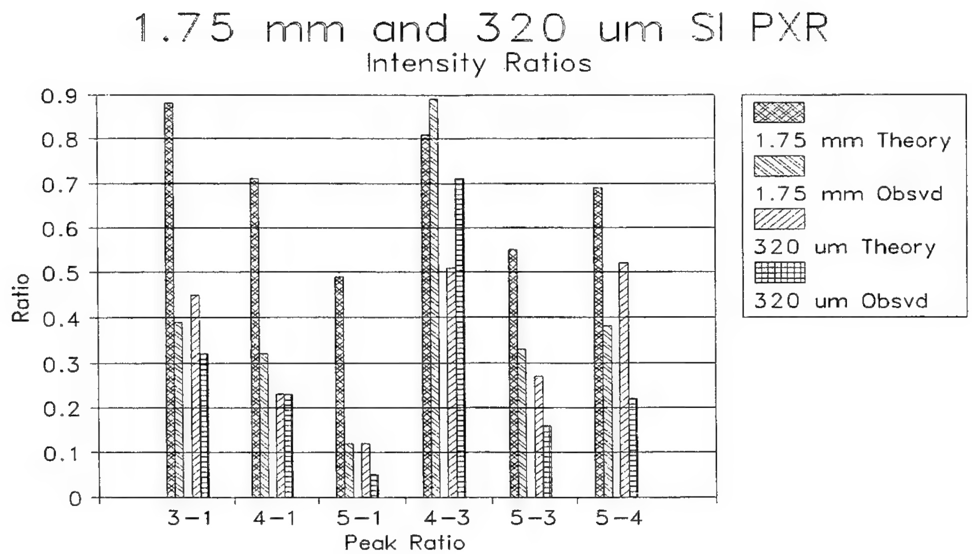


Figure 18. 1.75 mm and 320 μm Silicon Peak Intensity Ratios

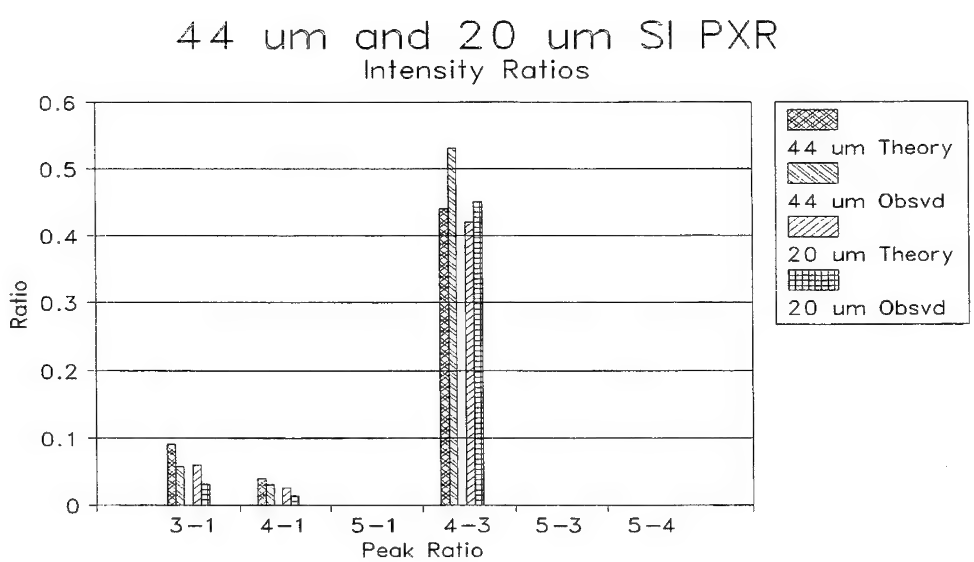


Figure 19. 44 μm and 20 μm Silicon Peak Intensity Ratios

VII. LITHIUM FLUORIDE CRYSTAL RESULTS

A. ENERGY PEAKS

The theoretical energy of observed PXR peaks is given by Equation 5. The 1 mm thick lithium fluoride monochromator has a crystal plane spacing of 0.1424 nm in the <220> orientation [Ref. 19]. For our experiment, the Bragg angle was, $\theta_B = 22.5°$. The theoretical and observed peak energies are compared in Table 9. The uncertainties listed in the table are the standard error of the energy calibration linear regression calculation. In all cases, the uncertainty of the energy calibration is larger than the uncertainty, determined by Peakfit, in the location of the particular energy peaks. The measured energy peaks are in good agreement with the expected results. The reduced electron beam energy during the 3 December data collection run seems to have had no effect on the energy peaks, thus confirming the geometrical interpretation of PXR as the scattering of virtual photons.

Peak n=	Theoretical Energy (keV)	22 Oct 92 (95 MeV Beam) Energy (keV)	01 Dec 92 (92 MeV Beam) Energy (keV)	03 Dec 92 (62 MeV Beam) Energy (keV)
1	11.4	11.2 ±0.13	11.4 ±0.14	11.3 ±0.3
2	22.8	22.3 ±0.13	23.0 ±0.14	23.0 ±0.3

Table 9. Lithium Fluoride Crystal PXR Energy Peaks.

B. PEAK INTENSITY RATIOS

As with the silicon data, the peak intensity ratios for lithium fluoride were calculated using Equation 21. The absorption length, L_a was determined by using the density [Ref. 20], and the photon attenuation coefficient μ determined by XCOM [Ref. 17], using Equation 29. The theoretical and observed intensity ratios are compared in Table 10. The uncertainties in the intensity ratios were determined by calculating the uncertainty in the area for each peak using data from the Peakfit numerical summary and then adding the fractional uncertainty for the peaks in question [Ref. 21]. The peak intensity ratio observed on 01 December, where the data is of much better quality, is in agreement with the calculated theoretical ratio. The uncertainties in the 22 October and the 03 December data are greater than 100% due to the small size of the n=2 peak in these data sets as seen in Appendices E5 and E6. Due to these large uncertainties the peak intensity ratios for the 22 October and 03 December data runs should be disregarded.

Peak Ratio	Theoretical Ratio	Observed 01 Dec 92 (92 MeV Beam)	Observed 22 Oct 92 (95 MeV Beam)	Observed 03 Dec 92 (62 MeV Beam)
2-1	.19	$.186 \pm .03$	$.082 \pm .1$	$.025 \pm .1$

Table 10. Lithium Fluoride PXR Peak Intensity Ratios.

C. 40 keV BACKGROUND DIP

An unexpected result was seen during all three data collection runs with the lithium fluoride crystal. As shown in Figure 20 and Appendices E4, E5 and E6, at about

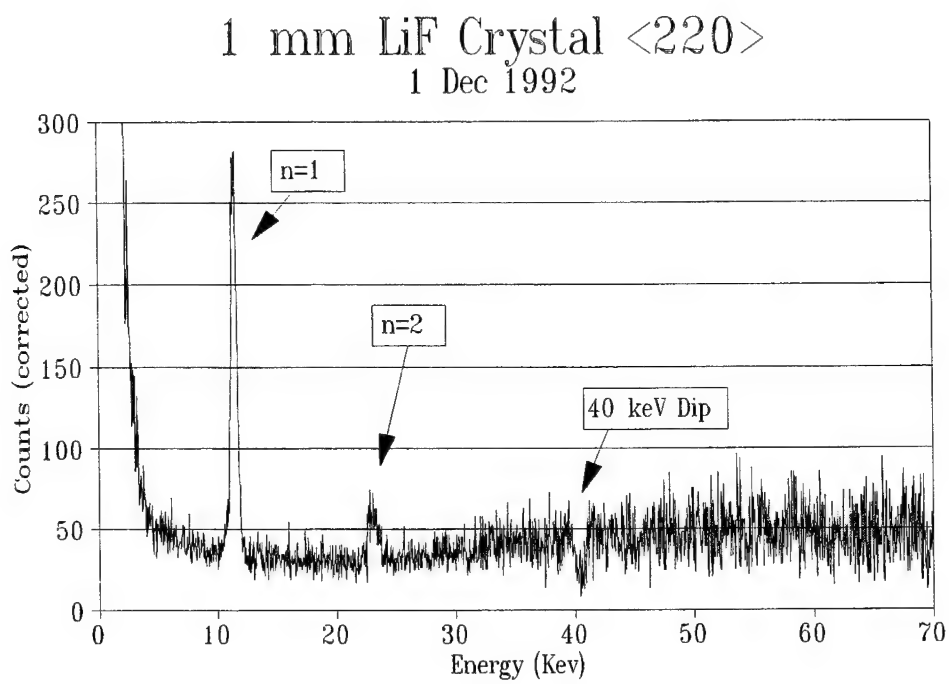


Figure 20. 40 keV background dip observed during Lithium Fluoride data collection runs.

40 keV a dip in the background was seen. This dip in the background was not observed during the silicon crystal data collection runs with the same experimental setup. The cause of this dip is an issue that remains open for exploration. It does not correspond to the energy of any known x-ray line. For now, it is an experimental anomaly.

VIII. CONCLUSIONS

Predicted PXR energy peak calculations are in good agreement with the observed peaks for silicon and for lithium fluoride.

Calculated PXR peak intensity ratios for silicon are not in agreement with the observed experimental results for thick silicon crystals (1.75 mm and 320 μm). The observed results for thin crystals (44 μm and 20 μm), are generally in agreement with the theory. The ratios observed in the 20 μm case are very close to the expected results. One factor that may be causing the observed divergence from theory is attenuation of the lower order PXR that is generated deep in the crystal as it travels to the surface. Predicted PXR peak intensity ratios for lithium fluoride are in agreement with the peak ratios observed in the 1 mm thick lithium fluoride crystal.

The appearance of the 40 keV dip in the background during the lithium luoride runs is puzzling. A brief search for an explanation failed to yield an answer and further exploration is required.

This experiment is the first observation of parametric x-radiation using lithium fluoride as a target. Due to the small spacing between the crystal planes the LiF PXR first order peak is above 10 keV. LiF shows promise as a source of high energy x-rays when compared to PXR from silicon.

IX. RECOMMENDATIONS

A. PXR EXPERIMENTS

Further exploration of PXR is certainly needed. The first step would seem to be analysis of different thicknesses of silicon crystals to resolve both the thin crystal energy peak question and to further explore the intensity ratio problem. As shown with lithium fluoride data can be taken at different beam energies using the NPS LINAC. This data might help to resolve some of the apparent differences between theory and practice.

Further data using the lithium fluoride crystal is also a logical next step. With longer data collection runs higher order peaks should be detectable and the 40 keV dip needs exploration.

Future PXR experiments could also include different crystal monochromators. Many suitable crystals are available, including quartz, indium antimonide, and germanium [Ref. 19].

B. EQUIPMENT

There were some equipment limitations encountered during this research. The power and stability problems of the LINAC probably require a general overhaul and tune up. Observed background radiation could probably be reduced with tighter radio frequency shielding of the accelerator end station and klystron gallery to eliminate as much klystron noise as possible.

Long range improvements which would aid in the further exploration of PXR would be a faster detector so data runs could be conducted at higher beam currents without double counting and a detector that has a wider range of energies which it can detect.

APPENDIX A. ENERGY CALIBRATION SPECTRUMS

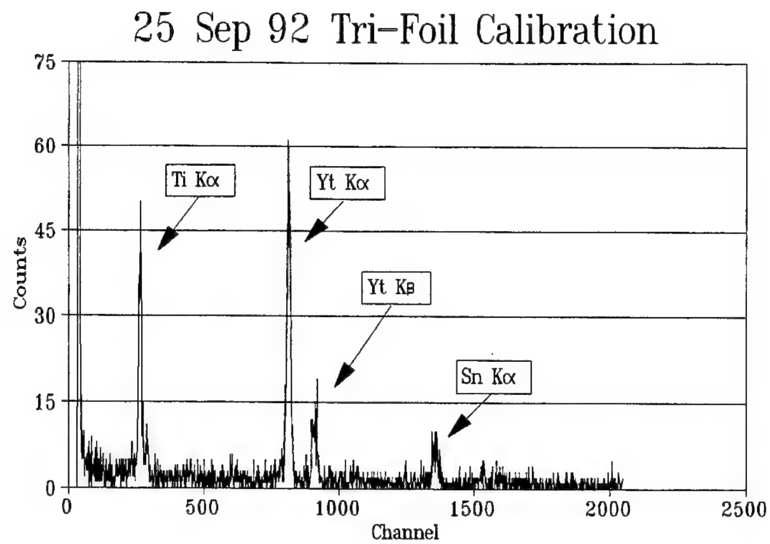
This appendix contains the as collected energy calibration spectrums as well as the Peakfit graphical and numerical analysis of the calibration peaks and concludes with the data and linear regression used to calculate the energy calibration.

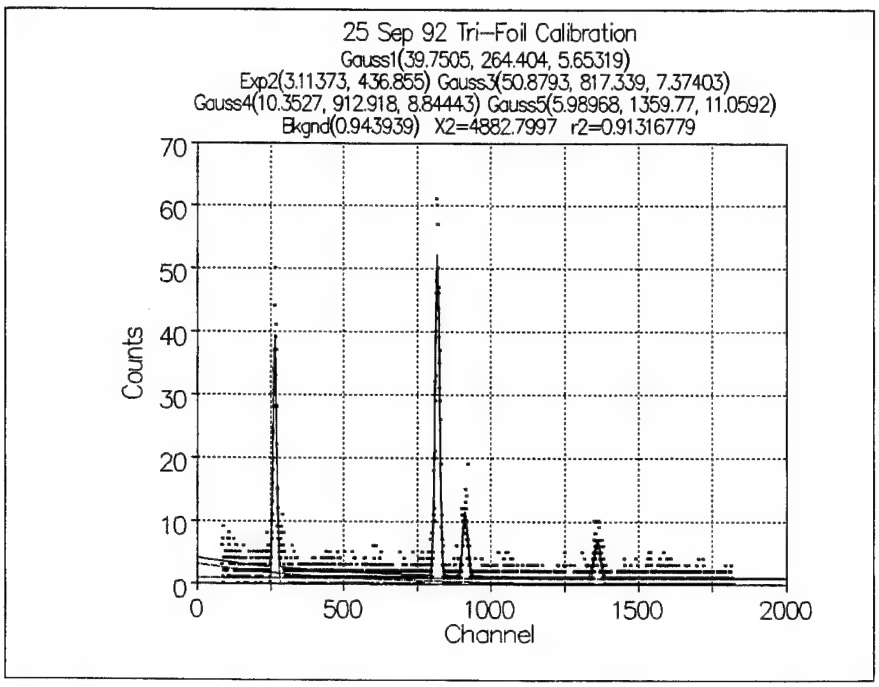
Section	Date	Beam Energy	Calibration	Target
A1	25 Sep 92	96 MeV	Tri Foil	Thick Si
A2	29-30 Sep 92	96 MeV	Tri Foil	Thick Si
A3	02 Dec 92	91 MeV	Tri Foil	Thick Si
A4	01 Dec 92	92 MeV	Tri Foil	LiF
A5	03 Dec 92	62 MeV	Tri Foil	LiF
A6	22 Oct 92	95 MeV	Tri Foil	LiF
A7	05 Sep 91	85 MeV	Ti,Cu Foil	Thin Si
A8	23 Jul 91	85 MeV	Ti,Cu Foil	Thin Si

Table 11. Energy Calibration Runs.

Sections A7 and A8 are calibration data used to analyze the thin silicon PXR spectrums reported on in Reference 5.

A1. ENERGY CALIBRATION DATA TAKEN ON 25 SEPTEMBER 1992





PeakFit Numerical Summary

Description: 25 Sep 92 Tri-Foil Calibration
X-Y Table Size: 2049 Active Points: 1740
X Variable: Channel
Y Variable: Counts
File Source: CAL925X4.PRN

Curve-Fit Std Error= 1.68244124 r2= 0.913167787

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	0.9439394			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	39.75051	264.4044	5.6531916		
2	Exp	3.1137273	436.85481			
3	Gaussian	50.879296	817.33949	7.3740329		
4	Gaussian	10.352699	912.91836	8.8444305		
5	Gaussian	5.9896774	1359.7728	11.059184		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	39.75051	264.4044	13.312229	563.28256	29.657523
2	Exp	0	0	0	0	0
3	Gaussian	50.879296	817.33949	17.364475	940.4505	49.515881
4	Gaussian	10.352699	912.91836	20.826956	229.51617	12.08431
5	Gaussian	5.9896774	1359.7728	26.042228	166.04144	8.7422869
	Total				1899.2907	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
39.75051039	264.4043968	13.31222926	563.2825625
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
257.7482841	271.0605133	6.65611269	6.656116574

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	39.75051039	0.653363159	60.83984053	38.47234391	41.02867687
Ctr	264.4043968	0.106904515	2473.27625	264.1952607	264.6135328
Wid1	5.65319158	0.108081629	52.30483318	5.44175279	5.864630369

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	3.113727307	0.244870718	12.71580097	2.634689671	3.592764944
Rtel	436.8548138	71.86411273	6.078900819	296.2679154	577.4417121

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
50.87929618	817.3394858	17.3644747	940.4505022
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
808.6572293	826.021704	8.682256575	8.682218123

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	50.87929618	0.571491251	89.02900276	49.76129473	51.99729763
Ctr	817.3394858	0.095385507	8568.801596	817.1528843	817.5260874
Wid1	7.374032898	0.096149905	76.69308531	7.185935996	7.5621298

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
10.35269944	912.9183567	20.82695556	229.5161726
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
902.5048714	923.3318269	10.41348536	10.4134702

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	10.35269944	0.521831497	19.83916169	9.331846763	11.37355211
Ctr	912.9183567	0.513399098	1778.184575	911.9140003	913.9227132
Wid1	8.84443049	0.517521786	17.08996748	7.832008852	9.856852127

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
5.989677371	1359.772755	26.04222811	166.0414396
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
1346.751653	1372.793881	13.02110294	13.02112517

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	5.989677371	0.467182583	12.82084905	5.07573371	6.903621032
Ctr	1359.772755	0.992276138	1370.357205	1357.831578	1361.713933
Widl	11.05918401	1.003537468	11.0202004	9.095975746	13.02239227

Background Order=0 Area=1641.5106393

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	0.943939413	0.104122444	9.065667064	0.740245929	1.147632897

Total Peaks= 5 Coefficient Count= 15 Fitted Count=15
Std Error for Curve= 1.682441241 r2= 0.9131677868

Source	Sum of Squares	DF	Mean Square	F
Regr	51349.784	14	3667.8417	1295.78
Error	4882.7997	1725	2.8306085	
Total	56232.584	1739		

25 Sep 92 Energy Calibration Linear Regression Calculation

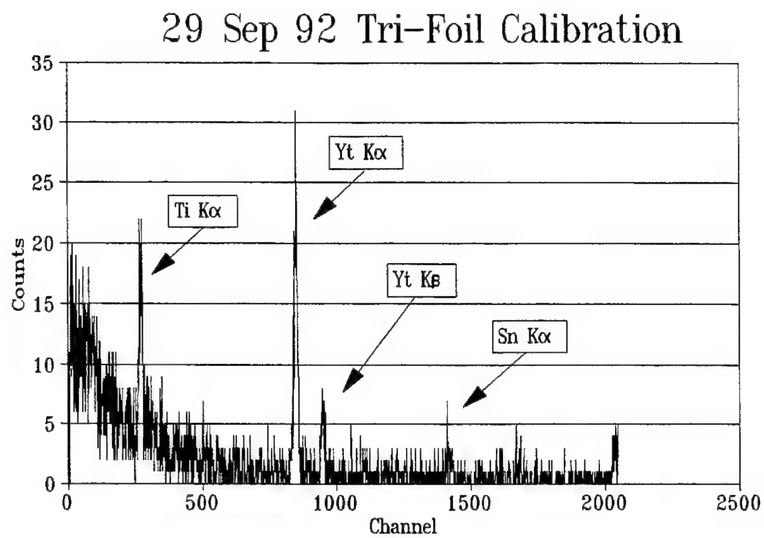
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	264.404	4.507
Yt	Kα	817.339	14.926
Yt	Kβ	912.918	16.874
Sn	Kα	1359.773	25.156

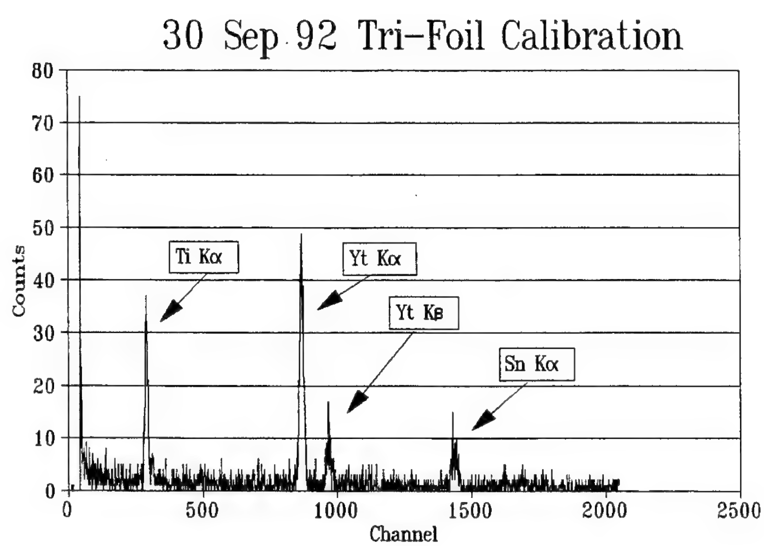
Regression Output:

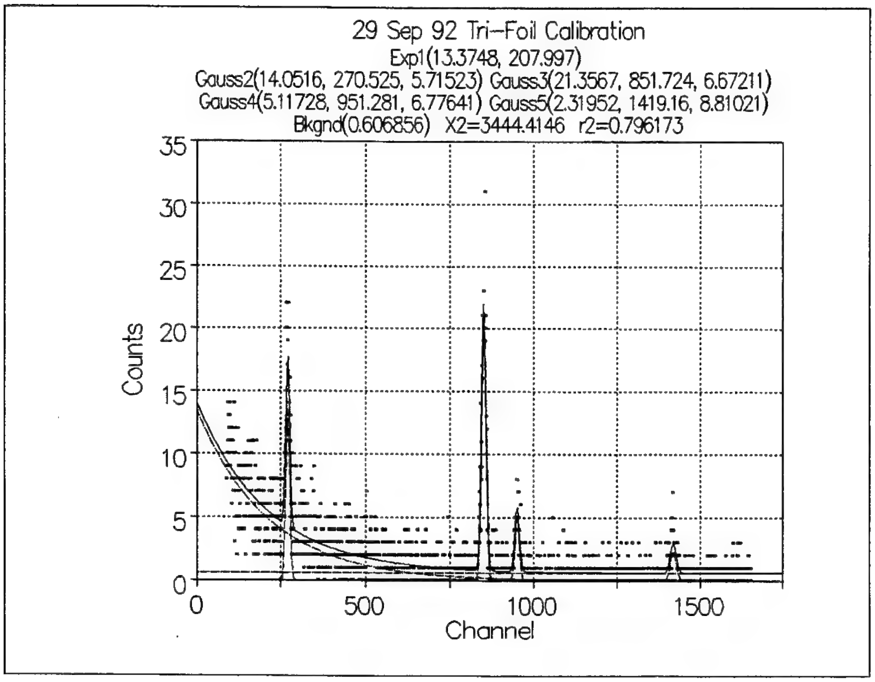
Constant	-0.45769
Std Err of Y Est	0.087221
R Squared	0.99993
No. of Observations	4
Degrees of Freedom	2

X Coefficient(s)	0.018869
Std Err of Coef.	0.000112

A2. ENERGY CALIBRATION DATA TAKEN 29-30 SEPTEMBER 1992







PeakFit Numerical Summary

```
Description:   29 Sep 92 Tri-Foil Calibration
X-Y Table Size: 2048   Active Points: 1567
X Variable: Channel
Y Variable: Counts
File Source: CAL929X3.PRN

Curve-Fit Std Error= 1.4897447      r2= 0.796173001

Background Coefficients [y=a+bx+cx^2+dx^3]
Background          a          b          c          d
     Order= 0    0.6068557
```

Curve-Fit Coefficients

Peak#	Type	Amp1	Rte1	Amp2	Rte2
1	Exp	13.374803	207.99687		
2	Gaussian	14.051629	270.52525	5.7152349	
3	Gaussian	21.356656	851.7238	6.6721124	
4	Gaussian	5.1172806	951.28139	6.7764128	
5	Gaussian	2.3195225	1419.1646	8.8102087	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Gaussian	14.051629	270.52525	13.458337	201.30322	28.89673
3	Gaussian	21.356656	851.7238	15.711563	357.18045	51.272637
4	Gaussian	5.1172806	951.28139	15.957158	86.921956	12.477497
5	Gaussian	2.3195225	1419.1646	20.746413	51.224134	7.353136
	Total				696.62975	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	13.37480346	0.483859262	27.6419292	12.42784531	14.32176161
Rte1	207.9968723	8.842537005	23.52230725	190.6911946	225.3025501

```
Peak# 2   Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  14.05162926   270.5252467   13.45833709   201.3032188
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  263.7960806   277.2544177   6.729166082   6.729171013
 Parm  Value        Std Error     t-value       95% Confidence Limits
 Ampl  14.05162926  0.576342916   24.38067489   12.92367189   15.17958663
  Ctr  270.5252467  0.269251155   1004.731983   269.9982968   271.0521965
 Widl  5.715234918  0.273520137   20.89511577   5.179930249   6.250539587

Peak# 3   Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  21.35665575   851.7237967   15.71156272   357.1804461
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  843.8680257   859.5795884   7.855771043   7.855791674
 Parm  Value        Std Error     t-value       95% Confidence Limits
 Ampl  21.35665575  0.531485191   40.18297428   20.31648917   22.39682232
  Ctr  851.7237967  0.191399293   4449.984025   851.3492103   852.0983831
 Widl  6.672112359  0.192392143   34.67975484   6.295582814   7.048641904

Peak# 4   Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  5.117280555   951.2813873   15.95715792   86.92195628
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  943.3027745   959.2599325   7.978612731   7.978545187
 Parm  Value        Std Error     t-value       95% Confidence Limits
 Ampl  5.117280555  0.527494495   9.701107032   4.084924145   6.149636965
  Ctr  951.2813873  0.805010463   1181.70065    949.705906    952.8568686
 Widl  6.776412797  0.809714365   8.368892901   5.191725521   8.361100074

Peak# 5   Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  2.319522503   1419.164563   20.7464125    51.22413363
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  1408.79135    1429.537763   10.3732124    10.3732001
 Parm  Value        Std Error     t-value       95% Confidence Limits
 Ampl  2.319522503  0.46339536    5.005493583   1.412614137   3.22643087
  Ctr  1419.164563  2.025041829   700.8075304   1415.201365   1423.12776
 Widl  8.810208686  2.047021865   4.303915282   4.803994093   12.81642328

Background   Order=0     Area=950.33608736
 Parm      Value        Std Error     t-value       95% Confidence Limits
  a       0.606855739   0.058030407   10.45754746   0.493284766   0.720426712

Total Peaks= 5    Coefficient Count= 15    Fitted Count=15
Std Error for Curve= 1.489744704      r2= 0.7961730012
Source     Sum of Squares     DF      Mean Square       F
Regr       13454.301          14      961.02153         433.021
Error      3444.4146          1552    2.2193393
Total      16898.716          1566
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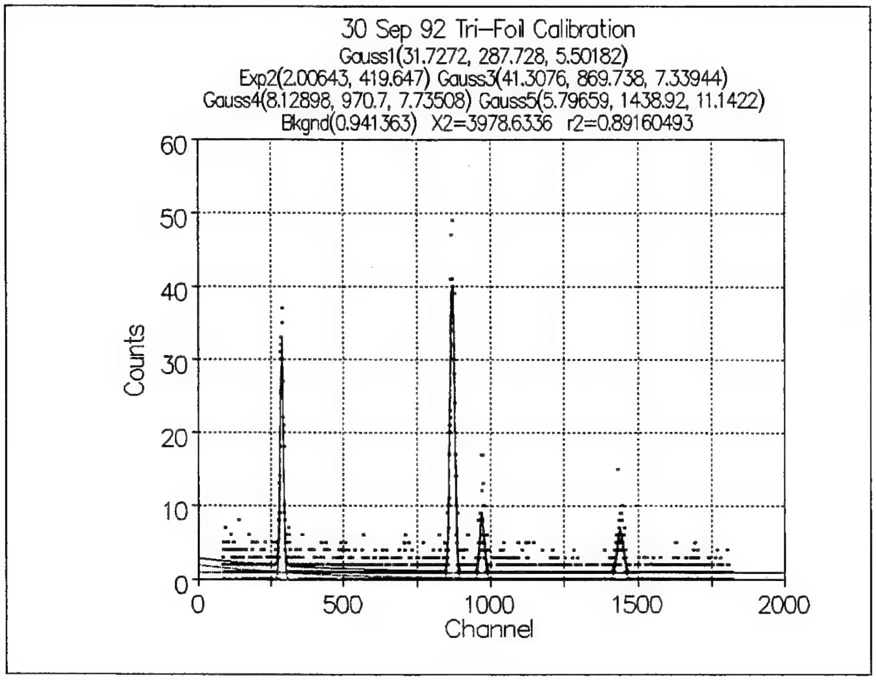


PeakFit Numerical Summary

```
Description: 30 Sep 92 Tri-Foil Calibration
X-Y Table Size: 2048   Active Points: 1740
X Variable: Channel
Y Variable: Counts
File Source: CAL930X4.PRN

Curve-Fit Std Error= 1.5187015      r2= 0.891604928
Background Coefficients [y=a+bx+cx^2+dx^3]
Background          a          b          c          d
     Order= 0    0.9413625

Curve-Fit Coefficients
Peak#  Type        Ampl        Ctr         Wid1        Wid2        Wid3
  1  Gaussian    31.727207   287.72831   5.5018151
  2  Exp         2.0064313   419.64714
  3  Gaussian    41.307595   869.73784   7.3394399
  4  Gaussian    8.1289771   970.70035   7.7350831
  5  Gaussian    5.7965891   1438.9181   11.142206

Measured Values
Peak#  Type        PkAmpl      PkCtr       Wid@HM      Area        %Area
  1  Gaussian    31.727207   287.72831   12.955757   437.55008   28.843071
  2  Exp         0           0           0           0           0
  3  Gaussian    41.307595   869.73784   17.283023   759.94444   50.095137
  4  Gaussian    8.1289771   970.70035   18.214672   157.6128    10.389753
  5  Gaussian    5.7965891   1438.9181   26.237758   161.89509   10.672039
     Total                                           1517.0024   100

Peak# 1  Gaussian
  PkAmpl       PkCtr        Wid@HM       Area
  31.72720656  287.7283123  12.95575696  437.5500831
  XL @HM       XR @HM       Ctr-XL@HM    Ctr-XR@HM
  281.250434   294.206191   6.477878312  6.477878649
 Parm  Value        Std Error    t-value      95% Confidence Limits
 Ampl  31.72720656  0.597588102  53.09209882  30.55815215  32.89626097
  Ctr  287.7283123  0.119272161  2412.367732  287.4949816  287.961643
 Wid1  5.501815083  0.120438597  45.68149418  5.266202505  5.737427661
```

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	2.006431324	0.227148763	8.833115793	1.562062934	2.450799713
Rtel	419.6471406	95.72628176	4.383823678	232.3789683	606.9153129

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
41.30759514	869.7378358	17.28302328	759.9444398
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
861.0963209	878.3793441	8.641514963	8.641508318

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	41.30759514	0.516896941	79.91456684	40.29639588	42.3187944
Ctr	869.7378358	0.105804763	8220.21442	869.5308512	869.9448204
Widl	7.339439941	0.106536923	68.89104481	7.131023041	7.54785684

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
8.128977082	970.700355	18.21467154	157.6127994
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
961.5930426	979.8077141	9.107312371	9.107359174

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	8.128977082	0.50339234	16.14839249	7.144196709	9.113757455
Ctr	970.700355	0.551951318	1758.670235	969.6205792	971.7801307
Widl	7.735083104	0.555404828	13.9269281	6.648551328	8.821614881

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
5.796589125	1438.918129	26.23775751	161.8950935
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
1425.799274	1452.037031	13.11885521	13.1189023

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	5.796589125	0.420403605	13.78815277	4.974158615	6.619019634
Ctr	1438.918129	0.929005811	1548.879579	1437.100726	1440.735532
Widl	11.14220624	0.941284019	11.83724148	9.300783642	12.98362883

Background Order=0 Area=1637.029426

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	0.941362522	0.090308527	10.42384976	0.764693037	1.118032007

Total Peaks= 5 Coefficient Count= 15 Fitted Count=15
Std Error for Curve= 1.518701504 r2= 0.8916049276

Source	Sum of Squares	DF	Mean Square	F
Regr	32726.297	14	2337.5926	1013.5
Error	3978.6336	1725	2.3064543	
Total	36704.93	1739		

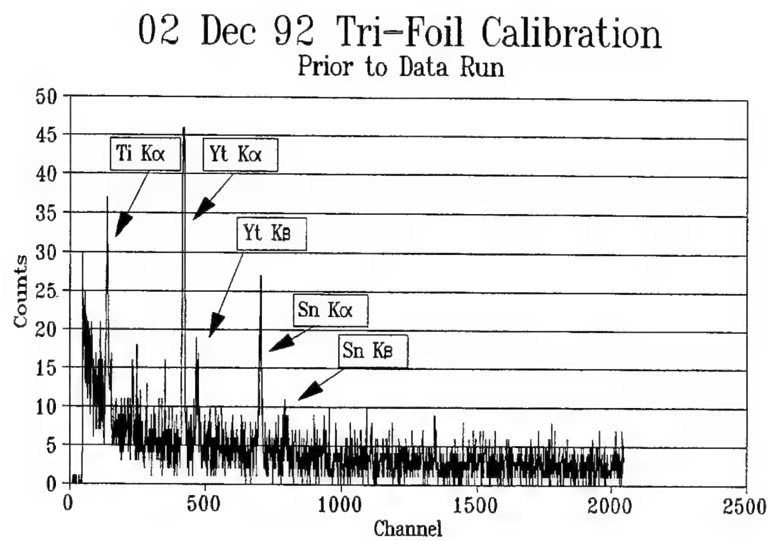
29 Sep 92 Energy Calibration Linear Regression Calculation

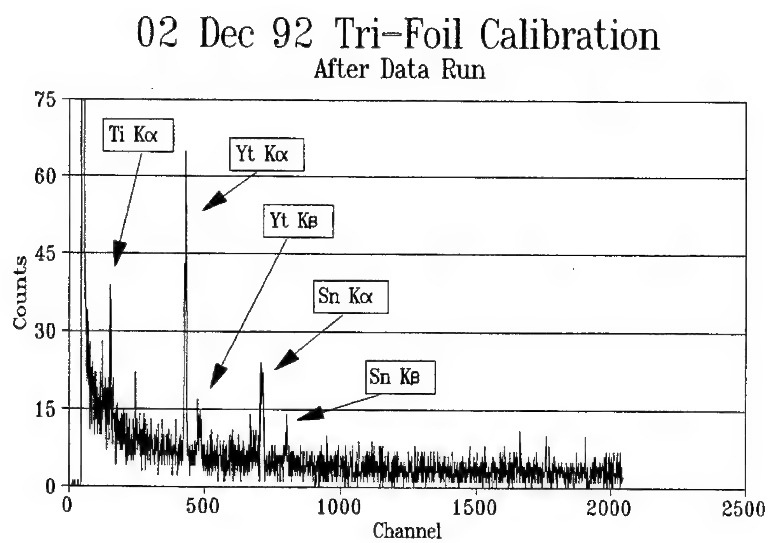
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	270.525	4.507
Yt	Kα	851.724	14.926
Yt	Kβ	951.281	16.874
Sn	Kα	1419.165	25.156
Ti	Kα	287.728	4.507
Yt	Kα	869.738	14.926
Yt	Kβ	970.7	16.874
Sn	Kα	1438.918	25.156

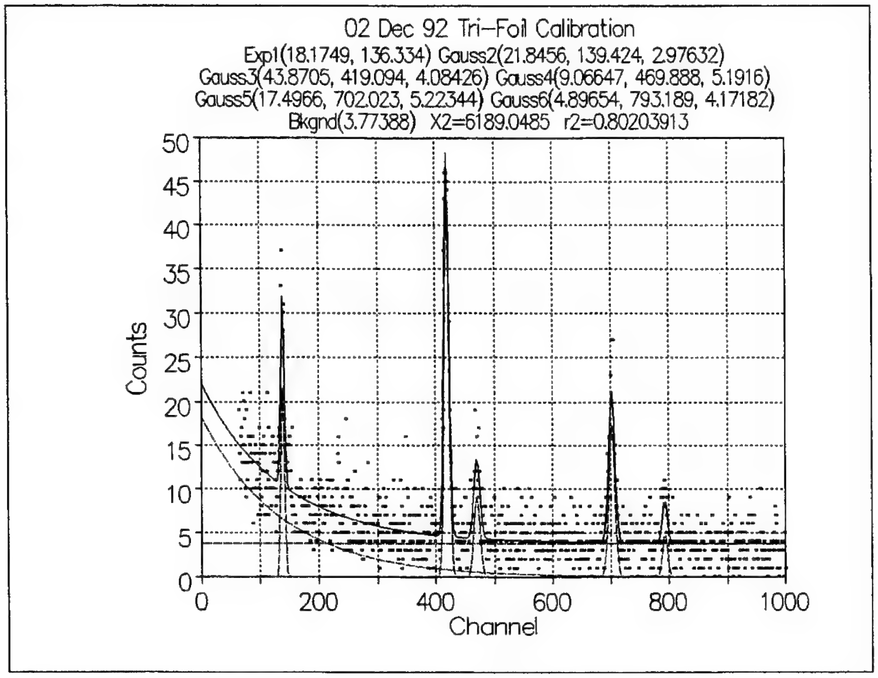
Regression Output:

Constant		-0.48599
Std Err of Y Est		0.20424
R Squared		0.999421
No. of Observations		8
Degrees of Freedom		6
X Coefficient(s)	0.017963	
Std Err of Coef.	0.000176	

A3. ENERGY CALIBRATION DATA TAKEN 02 DECEMBER 1992







PeakFit Numerical Summary

Description: 02 Dec 92 Tri-Foil Calibration
X-Y Table Size: 2048 Active Points: 936
X Variable: Channel
Y Variable: Counts
File Source: CM1202X2.PRN

Curve-Fit Std Error= 2.5965136 r2= 0.802039129

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	3.7738825			

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	18.174903	136.33402		
2	Gaussian	21.845597	139.4237	2.9763176	
3	Gaussian	43.870546	419.09413	4.0842593	
4	Gaussian	9.0664736	469.888	5.1916002	
5	Gaussian	17.496633	702.0232	5.2234369	
6	Gaussian	4.8965373	793.18865	4.1718216	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Gaussian	21.845597	139.4237	7.0086881	162.97956	16.130332
3	Gaussian	43.870546	419.09413	9.6176818	449.13525	44.451591
4	Gaussian	9.0664736	469.888	12.225253	117.98575	11.677228
5	Gaussian	17.496633	702.0232	12.300189	229.08713	22.673098
6	Gaussian	4.8965373	793.18865	9.8238183	51.204144	5.0677511
	Total				1010.3918	100

```
Peak# 1  Exp
  PkAmpl        PkCtr         Wid@HM        Area
  0             0             0             0
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  0             0             0             0
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  18.17490324   1.187089105   15.31047936   15.84759982   20.50220667
 Rtel  136.334023    9.966010967   13.67989895   116.7955306   155.8725154

Peak# 2  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  21.84559705   139.4237025   7.008688131   162.979562
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  135.9193567   142.9280448   3.504345835   3.504342296
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  21.84559705   1.3913451     15.70106299   19.11784713   24.57334698
  Ctr  139.4237025   0.217846434   640.0091101   138.9966118   139.8507932
 Wid1  2.976317623   0.22101011    13.46688446   2.543024464   3.409610781

Peak# 3  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  43.87054597   419.0941334   9.617681847   449.1352494
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  414.2852962   423.902978    4.808837218   4.80884463
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  43.87054597   1.184535873   37.03606363   41.54824819   46.19284375
  Ctr  419.0941334   0.127059726   3298.402612   418.8450311   419.3432356
 Wid1  4.084259304   0.12789628    31.93415235   3.833517004   4.335001603

Peak# 4  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  9.066473588   469.8879984   12.22525335   117.9857536
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  463.7753813   476.0006346   6.112617181   6.112636169
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  9.066473588   1.050838079   8.627850257   7.006292046   11.12665513
  Ctr  469.8879984   0.693170087   677.8826835   468.5290296   471.2469673
 Wid1  5.191600206   0.698117819   7.436567392   3.822931261   6.56026915

Peak# 5  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  17.49663278   702.0231986   12.30018876   229.0871267
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  695.8731172   708.1733059   6.150081375   6.150107382
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  17.49663278   1.048459578   16.68794215   15.44111432   19.55215124
  Ctr  702.0231986   0.360282405   1948.535897   701.3168603   702.7295368
 Wid1  5.223436929   0.363709891   14.36154764   4.510379019   5.93649484

Peak# 6  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  4.89653725    793.18865     9.823818317   51.20414359
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  788.276747    798.1005653   4.911902991   4.911915326
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  4.89653725    1.17282562    4.174991717   2.597197568   7.195876932
  Ctr  793.18865     1.150514682   689.420711    790.9330512   795.4442488
 Wid1  4.1718216     1.160410625   3.595125303   1.896821674   6.446821525

Background  Order=0    Area=3528.5801517
 Parm    Value         Std Error     t-value       95% Confidence Limits
  a    3.773882515   0.137809808   27.38471645   3.503704618   4.044060413

Total Peaks= 6   Coefficient Count= 18   Fitted Count=18
Std Error for Curve= 2.596513598        r2= 0.8020391287
Source    Sum of Squares     DF      Mean Square        F
Regr      25074.95           17      1474.9971          218.781
Error     6189.0485          918     6.7418829
Total     31263.999          935
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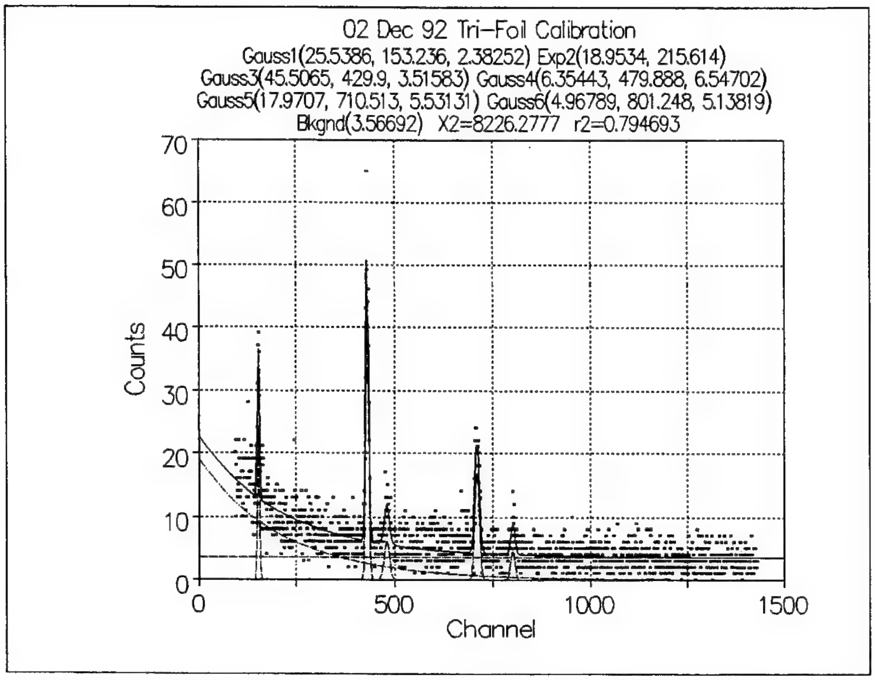


PeakFit Numerical Summary

Description: 02 Dec 92 Tri-Foil Calibration
X-Y Table Size: 2048 Active Points: 1336
X Variable: Channel
Y Variable: Counts
File Source: CM1202X3.PRN

Curve-Fit Std Error= 2.49829649 r2= 0.794693002

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	3.5669181			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	25.538596	153.23611	2.3825152		
2	Exp	18.953434	215.61415			
3	Gaussian	45.506535	429.90035	3.5158277		
4	Gaussian	6.3544321	479.88818	6.5470224		
5	Gaussian	17.970671	710.51314	5.5313125		
6	Gaussian	4.9678881	801.24796	5.1381925		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	25.538596	153.23611	5.6103753	152.51853	15.707532
2	Exp	0	0	0	0	0
3	Gaussian	45.506535	429.90035	8.2791066	401.04333	41.302528
4	Gaussian	6.3544321	479.88818	15.417031	104.2822	10.739784
5	Gaussian	17.970671	710.51314	13.025187	249.16197	25.660617
6	Gaussian	4.9678881	801.24796	12.099487	63.983743	6.5895382
	Total				970.98978	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
25.53859583	153.2361059	5.610375343	152.5185315
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
150.4309182	156.0412936	2.805187689	2.805187655

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	25.53859583	1.496154022	17.06949649	22.60875969	28.46843196
Ctr	153.2361059	0.160403909	955.3140373	152.9219957	153.5502161
Wid1	2.382515224	0.162714026	14.64234697	2.063881296	2.701149151

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	18.95343421	0.875002421	21.66100773	17.23996509	20.66690332
Rtel	215.6141482	11.89380562	18.12827239	192.3231628	238.9051336

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
45.50653546	429.9003537	8.279106552	401.0433287
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
425.7607952	434.0399018	4.139558486	4.139548066

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	45.50653546	1.229245791	37.01988308	43.09937103	47.91369988
Ctr	429.9003537	0.109348501	3931.470007	429.6862226	430.1144849
Wid1	3.515827748	0.110290137	31.87798876	3.299852638	3.731802857

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
6.354432059	479.8881822	15.41703145	104.2822029
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
472.1796587	487.5966901	7.708523516	7.708507931

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	6.354432059	0.902300672	7.042477366	4.58750628	8.121357839
Ctr	479.8881822	1.068625443	449.0705191	477.7955518	481.9808126
Wid1	6.547022407	1.083083118	6.044801454	4.426080306	8.667964508

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
17.97067085	710.5131383	13.02518729	249.1619724
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
704.0005333	717.0257205	6.512605079	6.512582213

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	17.97067085	0.978953115	18.35702914	16.05364081	19.88770089
Ctr	710.5131383	0.347316147	2045.724464	709.8330082	711.1932684
Wid1	5.531312485	0.349168266	15.84139516	4.847555473	6.215069497

Peak# 6 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
4.967888119	801.2479567	12.09948676	63.98374276
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
795.1982122	807.297699	6.049744435	6.049742326

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	4.967888119	1.015510821	4.892009044	2.979269132	6.956507106
Ctr	801.2479567	1.210896031	661.6983918	798.8767256	803.6191878
Wid1	5.138192529	1.216636131	4.223277937	2.755720909	7.520664149

Background Order=0 Area=4761.8356232

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	3.56691807	0.113535587	31.41674057	3.344587575	3.789248565

Total Peaks= 6 Coefficient Count= 18 Fitted Count=18

Std Error for Curve= 2.498296486 r2= 0.7946930023

Source	Sum of Squares	DF	Mean Square	F
Regr	31841.902	17	1873.0531	300.097
Error	8226.2777	1318	6.2414853	
Total	40068.18	1335		

2 Dec 92 Energy Calibration Linear Regression Calculation

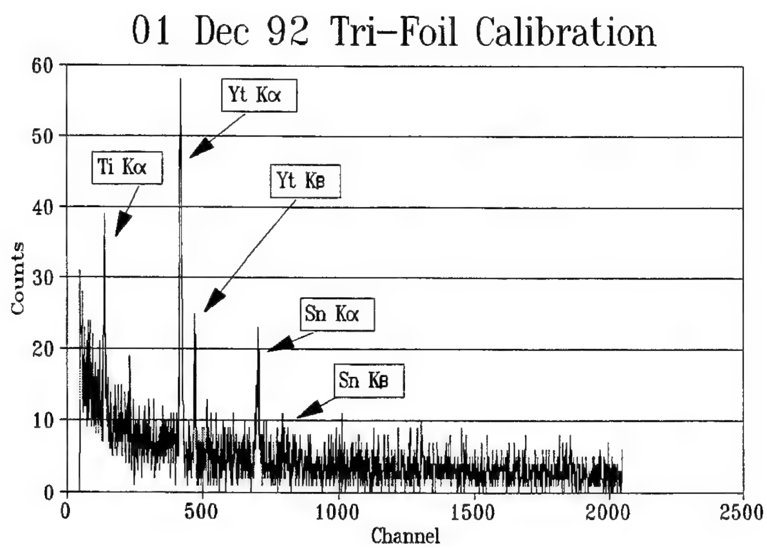
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	139.424	4.507
Yt	Kα	419.094	14.926
Yt	Kβ	469.888	16.874
Sn	Kα	702.023	25.156
Sn	Kβ	793.189	28.795
Ti	Kα	153.236	4.507
Yt	Kα	429.9	14.926
Yt	Kβ	479.888	16.874
Sn	Kα	710.516	25.156
Sn	Kβ	801.248	28.795

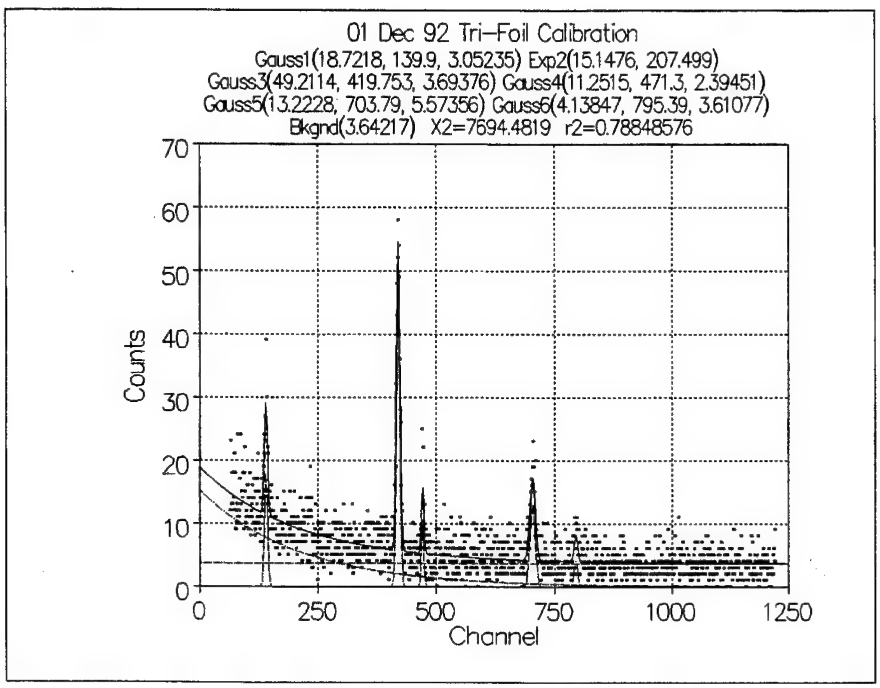
Regression Output:

Constant	-0.85577
Std Err of Y Est	0.248394
R Squared	0.999315
No. of Observations	10
Degrees of Freedom	8

X Coefficient(s)	0.037085
Std Err of Coef.	0.000343

A4. ENERGY CALIBRATION DATA TAKEN 01 DECEMBER 1992





PeakFit Numerical Summary

Description: 01 Dec 92 Tri-Foil Calibration
X-Y Table Size: 2048   Active Points: 1158
X Variable: Channel
Y Variable: Counts
File Source: CAM12013.PRN

Curve-Fit Std Error= 2.59798875   r2= 0.788485758

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	3.6421668			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	18.721774	139.9003	3.0523507		
2	Exp	15.147649	207.49869			
3	Gaussian	49.211393	419.75301	3.6937643		
4	Gaussian	11.251475	471.30001	2.3945063		
5	Gaussian	13.222807	703.79025	5.5735618		
6	Gaussian	4.1384652	795.38972	3.6107706		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	18.721774	139.9003	7.1877174	143.24229	16.119842
2	Exp	0	0	0	0	0
3	Gaussian	49.211393	419.75301	8.6981249	455.64305	51.276017
4	Gaussian	11.251475	471.30001	5.6386007	67.532757	7.5998324
5	Gaussian	13.222807	703.79025	13.124711	184.73374	20.789103
6	Gaussian	4.1384652	795.38972	8.5025889	37.456672	4.2152052
	Total				888.60851	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
18.72177407	139.9002963	7.187717422	143.2422898
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
136.306436	143.4941534	3.593860322	3.5938571

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	18.72177407	1.374583535	13.61996096	16.02870312	21.41484503
Ctr	139.9002963	0.257556971	543.1819451	139.3956931	140.4048994
Wid1	3.052350733	0.261260805	11.68315597	2.540491055	3.564210412

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	15.14764854	0.711817901	21.28022984	13.75306169	16.54223538
Rtel	207.4986946	13.84359475	14.98878711	180.3764558	234.6209335

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
49.21139331	419.7530068	8.69812489	455.6430496
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
415.4039443	424.1020692	4.349062433	4.349062457

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	49.21139331	1.2468732	39.46784108	46.76853122	51.65425539
Ctr	419.7530068	0.107779398	3894.556983	419.5418464	419.9641671
Wid1	3.693764321	0.108641542	33.99955723	3.480914848	3.906613794

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
11.25147465	471.3000135	5.638600663	67.5327569
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
468.4807041	474.1193047	2.819309434	2.819291229

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	11.25147465	1.546681801	7.274589152	8.221230411	14.28171889

Ctr	471.3000135	0.379545559	1241.748196	470.5564115	472.0436156
Widl	2.394506304	0.381152137	6.282284878	1.647756672	3.141255935

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
13.22280657	703.7902521	13.12471149	184.7337368
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
697.2278934	710.3526049	6.56235864	6.562352847

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	13.22280657	1.014386203	13.0352784	11.23543079	15.21018235
Ctr	703.7902521	0.492732699	1428.34087	702.8248949	704.7556093
Widl	5.5735618	0.495699919	11.2438223	4.602391245	6.544732355

Peak# 6 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
4.138465231	795.3897237	8.502588904	37.45667209
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
791.138434	799.6410229	4.251289686	4.251299218

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	4.138465231	1.259613796	3.285503257	1.670641891	6.606288571
Ctr	795.3897237	1.267144324	627.7025502	792.9071466	797.8723008
Widl	3.610770623	1.272755518	2.8369711	1.117200146	6.1043411

Background Order=0 Area=4213.986932

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	3.642166752	0.138192453	26.35575734	3.371421416	3.912912088

PeakFit Numerical Summary Aug 20,1993 4:47 PM Pg. 3

Total Peaks= 6 Coefficient Count= 18 Fitted Count=18
Std Error for Curve= 2.597988749 r2= 0.7884857575

Source	Sum of Squares	DF	Mean Square	F
Regr	28683.598	17	1687.2704	249.983
Error	7694.4819	1140	6.7495455	
Total	36378.079	1157		

1 Dec 92 Energy Calibration Linear Regression Calculation

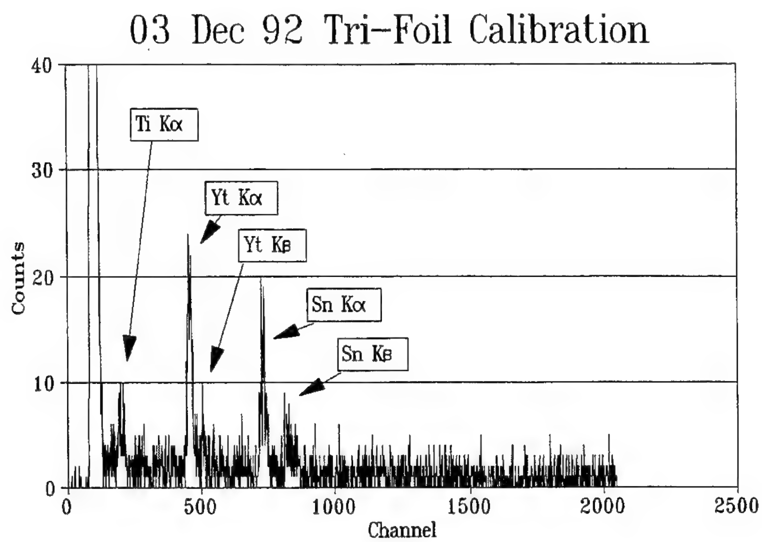
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	139.9	4.507
Yt	Kα	419.753	14.926
Yt	Kβ	471.3	16.874
Sn	Kα	703.79	25.156
Sn	Kβ	795.39	28.795

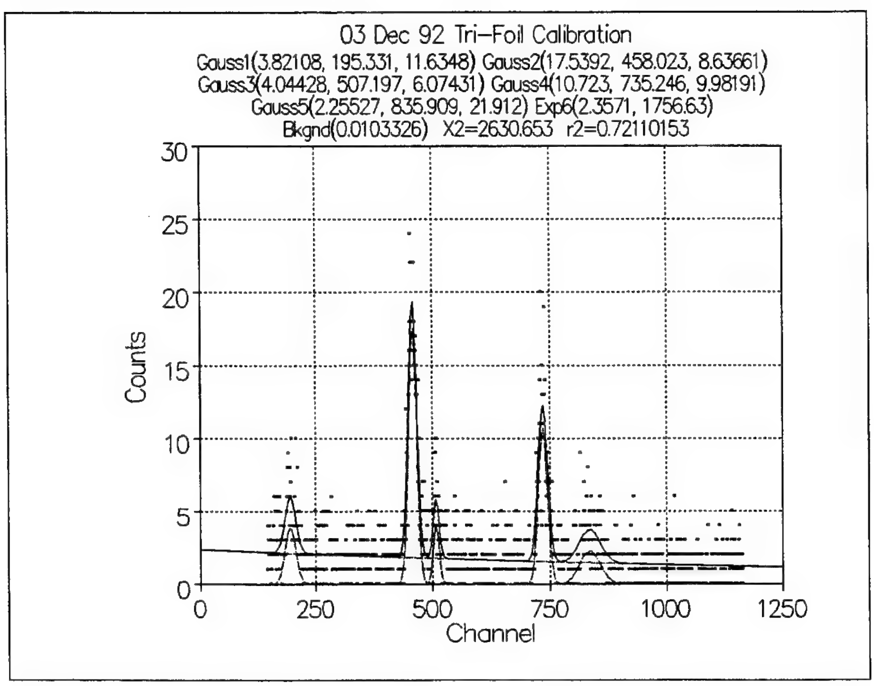
Regression Output:

Constant	-0.59206
Std Err of Y Est	0.136727
R Squared	0.999844
No. of Observations	5
Degrees of Freedom	3

X Coefficient(s)	0.036843
Std Err of Coef.	0.000265

A5. ENERGY CALIBRATION DATA TAKEN 03 DECEMBER 1992





PeakFit Numerical Summary

Description: 03 Dec 92 Tri-Foil Calibration
X-Y Table Size: 2048   Active Points: 1019
X Variable: Channel
Y Variable: Counts
File Source: CM1203X3.PRN

Curve-Fit Std Error= 1.62111844   r2= 0.721101531

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	0.0103326			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	3.8210819	195.33118	11.634837		
2	Gaussian	17.53916	458.02276	8.6366127		
3	Gaussian	4.0442837	507.1969	6.0743102		
4	Gaussian	10.72304	735.24594	9.9819079		
5	Gaussian	2.2552665	835.90881	21.91197		
6	Exp	2.3570975	1756.6334			

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	3.8210819	195.33118	27.39794	111.43798	11.793757
2	Gaussian	17.53916	458.02276	20.337649	379.70197	40.184799
3	Gaussian	4.0442837	507.1969	14.303885	61.578419	6.5169964
4	Gaussian	10.72304	735.24594	23.505543	268.30028	28.394883
5	Gaussian	2.2552665	835.90881	51.598654	123.87091	13.109565
6	Exp	0	0	0	0	0
	Total				944.88955	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
3.821081923	195.3311761	27.39794017	111.4379776
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
181.6322061	209.0301462	13.69896999	13.69897017

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	3.821081923	0.45323636	8.430660596	2.932741401	4.709422446
Ctr	195.3311761	1.540352192	126.8094252	192.3120951	198.350257
Wid1	11.63483738	1.702403024	6.83436132	8.298137758	14.971537

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
17.53916043	458.022762	20.33764894	379.7019691
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
447.8539319	468.1915809	10.1688301	10.16881884

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	17.53916043	0.511117984	34.31528725	16.53737228	18.54094859
Ctr	458.022762	0.288580493	1587.157735	457.457146	458.5883781
Wid1	8.636612701	0.294618277	29.31458561	8.059162662	9.21406274

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
4.044283718	507.1969001	14.30388541	61.5784185
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
500.0449678	514.3488532	7.151932326	7.151953085

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	4.044283718	0.608480776	6.646526694	2.851665081	5.236902355
Ctr	507.1969001	1.049454407	483.295793	505.1399758	509.2538244
Wid1	6.074310235	1.066614673	5.694943443	3.983751934	8.164868537

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
10.72304008	735.2459361	23.5055432	268.3002811
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
723.4931912	746.9987344	11.75274486	11.75279834

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	10.72304008	0.476811282	22.48906534	9.788492849	11.6575873
Ctr	735.2459361	0.50742617	1448.971259	734.2513839	736.2404883
Wid1	9.981907941	0.521835567	19.12845458	8.959113388	11.00470249

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
2.255266526	835.9088083	51.5986544	123.8709064
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
810.1094918	861.7081462	25.79931644	25.79933796

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	2.255266526	0.324475572	6.950497118	1.619296369	2.891236682
Ctr	835.9088083	3.579650114	233.5169029	828.8927157	842.9249008
Wid1	21.91197013	3.755429229	5.834744525	14.55135158	29.27258869

Peak# 6 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	2.357097497	4.601705509	0.512222586	-6.66221745	11.37641244
Rtel	1756.633426	5392.278223	0.325768321	-8812.19925	12325.4661

Background Order=0 Area=10.518574897

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	0.010332588	4.944983601	0.002089509	-9.68180534	9.702470512

Total Peaks= 6 Coefficient Count= 18 Fitted Count=18
Std Error for Curve= 1.621118439 r2= 0.7211015307

Source	Sum of Squares	DF	Mean Square	F
Regr	6801.6433	17	400.09667	152.242
Error	2630.653	1001	2.628025	
Total	9432.2964	1018		

3 Dec 92 Energy Calibration Linear Regression Calculation

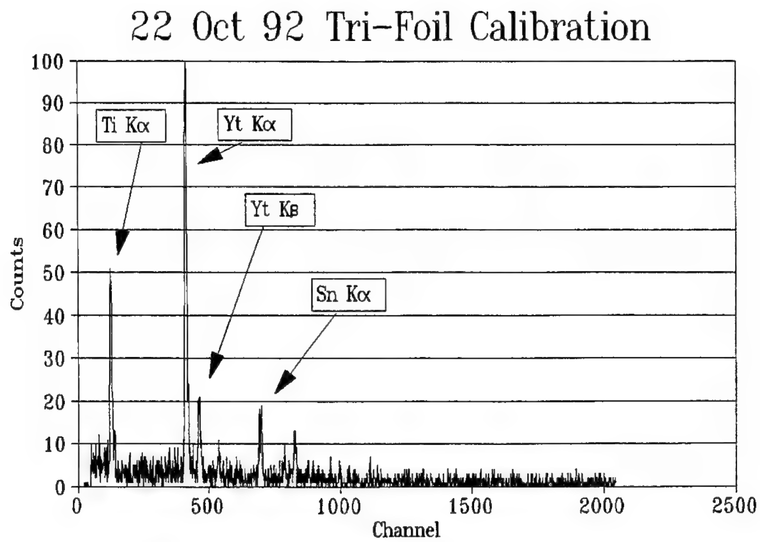
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	195.331	4.507
Yt	Kα	458.023	14.926
Yt	Kß	507.197	16.874
Sn	Kα	735.246	25.156
Sn	Kß	835.909	28.795

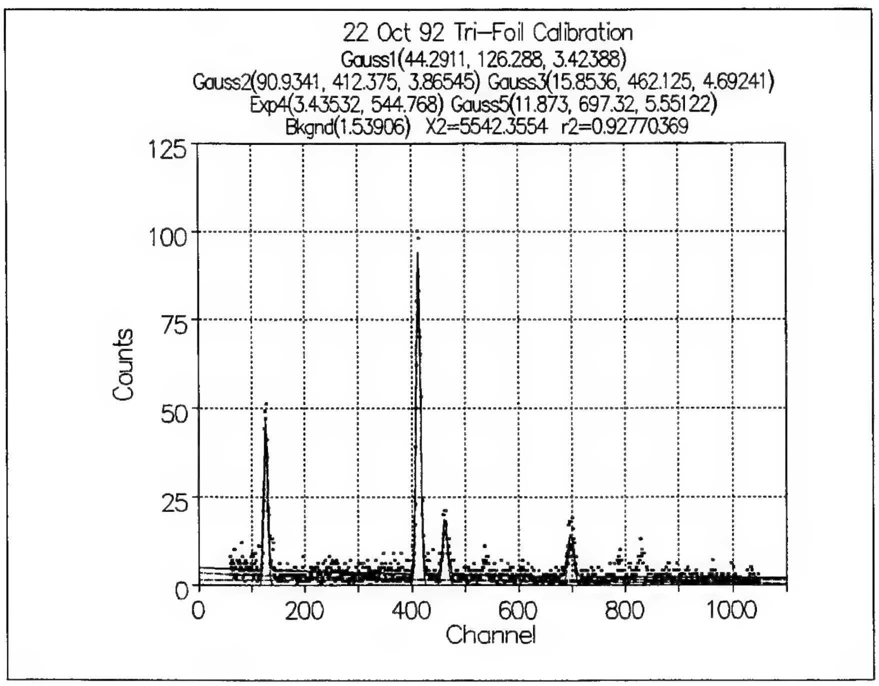
Regression Output:

Constant	-2.60226
Std Err of Y Est	0.291635
R Squared	0.999292
No. of Observations	5
Degrees of Freedom	3

X Coefficient(s)	0.037804
Std Err of Coef.	0.000581

A6. ENERGY CALIBRATION DATA TAKEN 22 OCTOBER 1992





PeakFit Numerical Summary

Description: 22 Oct 92 Tri-Foil Calibration
X-Y Table Size: 2048   Active Points: 991
X Variable: Channel
Y Variable: Counts
File Source: CL1022X1.PRN

Curve-Fit Std Error= 2.38299031   r2= 0.927703694

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	1.5390613			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	44.291144	126.28816	3.4238806		
2	Gaussian	90.934061	412.37526	3.865454		
3	Gaussian	15.853636	462.12518	4.6924072		
4	Exp	3.43532	544.76793			
5	Gaussian	11.872979	697.32025	5.5512234		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	44.291144	126.28816	8.0626206	380.12415	23.567907
2	Gaussian	90.934061	412.37526	9.1024312	881.08155	54.627542
3	Gaussian	15.853636	462.12518	11.04976	186.47244	11.561394
4	Exp	0	0	0	0	0
5	Gaussian	11.872979	697.32025	13.072051	165.21074	10.243157
	Total				1612.8889	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
44.29114398	126.2881607	8.06262062	380.1241476
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
122.2568512	130.3194718	4.031309502	4.031311118

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	44.29114398	1.192204975	37.1506116	41.9542474	46.62804057
Ctr	126.2881607	0.10575926	1194.109726	126.080857	126.4954643
Wid1	3.423880632	0.107745265	31.77755094	3.212684114	3.635077151

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
90.93406139	412.3752617	9.102431195	881.0815472
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
407.824047	416.9264782	4.55121473	4.551216465

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	90.93406139	1.11856601	81.29521242	88.74150798	93.1266148
Ctr	412.3752617	0.054729965	7534.725421	412.267983	412.4825405
Wid1	3.865454017	0.055250181	69.96273996	3.757155561	3.973752473

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
15.85363615	462.1251813	11.04975969	186.4724377
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
456.6002978	467.6500575	5.524883487	5.5248762

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	15.85363615	1.015843375	15.60637844	13.86243417	17.84483813
Ctr	462.1251813	0.345876623	1336.098338	461.4472124	462.8031502
Wid1	4.692407157	0.34978566	13.415093	4.00677597	5.378038345

Peak# 4 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	3.435320002	0.492289731	6.978248353	2.470359939	4.400280065
Rte1	544.7679327	273.040933	1.995187779	9.567664262	1079.968201

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
11.87297866	697.3202483	13.07205135	165.2107449
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
690.7842489	703.8563003	6.535999341	6.53605201

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	11.87297866	0.93309403	12.72431103	10.04397753	13.7019798
Ctr	697.3202483	0.502335621	1388.156085	696.3355968	698.3048998
Widl	5.551223396	0.506613984	10.95750131	4.558185695	6.544261097

Background Order=0 Area=1523.6706559

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	1.539061269	0.689794804	2.2311871	0.186962299	2.891160238

Total Peaks= 5 Coefficient Count= 15 Fitted Count=15
Std Error for Curve= 2.382990306 r2= 0.9277036935

Source	Sum of Squares	DF	Mean Square	F
Regr	71119.312	14	5079.9508	894.571
Error	5542.3554	976	5.6786428	
Total	76661.667	990		

22 Oct 92 Energy Calibration Linear Regression Calculation

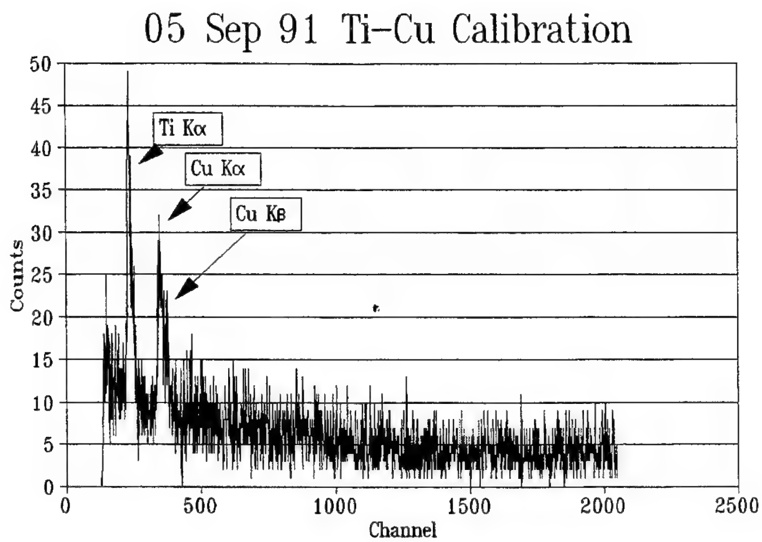
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	126.288	4.507
Yt	Kα	412.375	14.926
Yt	Kβ	462.125	16.874
Sn	Kα	697.32	25.156

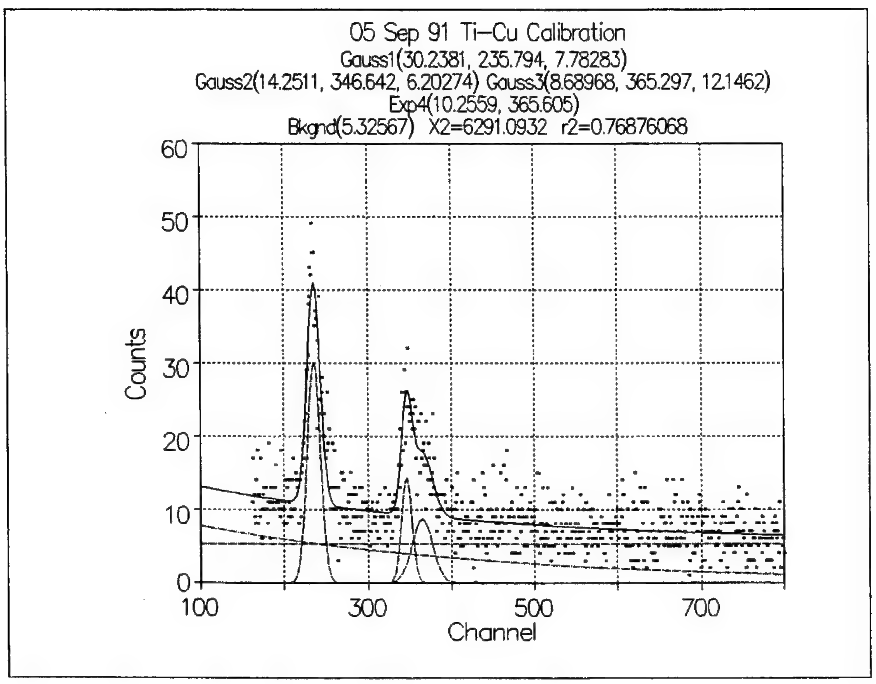
Regression Output:

Constant	-0.00476
Std Err of Y Est	0.128002
R Squared	0.999848
No. of Observations	4
Degrees of Freedom	2

X Coefficient(s)	0.036206
Std Err of Coef.	0.000315

A7. ENERGY CALIBRATION DATA TAKEN 05 SEPTEMBER 1991





PeakFit Numerical Summary

Description: 05 Sep 91 Ti-Cu Calibration
X-Y Table Size: 2048   Active Points: 639
X Variable: Channel
Y Variable: Counts
File Source: CL905X1.PRN

Curve-Fit Std Error= 3.16759238   r2= 0.768760684

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	5.3256698			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	30.238108	235.794	7.7828328		
2	Gaussian	14.251083	346.64223	6.2027359		
3	Gaussian	8.6896818	365.2966	12.146242		
4	Exp	10.25587	365.60494			

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	30.238108	235.794	18.327154	589.90522	54.821725
2	Gaussian	14.251083	346.64223	14.606299	221.5705	20.591235
3	Gaussian	8.6896818	365.2966	28.602186	264.56707	24.58704
4	Exp	0	0	0	0	0
	Total				1076.0428	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
30.23810849	235.794001	18.32715432	589.905218
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
226.6304318	244.9575861	9.163569163	9.163585153

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	30.23810849	1.061892236	28.47568471	28.15387682	32.32234016
Ctr	235.794001	0.310965137	758.2650694	235.1836534	236.4043486
Wid1	7.782832765	0.325859885	23.88398549	7.143250452	8.422415078

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
14.25108343	346.6422274	14.60629914	221.570501
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
339.3390739	353.945373	7.303153558	7.303145579

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	14.25108343	3.885374055	3.667879393	6.625055676	21.87711118
Ctr	346.6422274	1.047959489	330.7782707	344.5853423	348.6991126
Wid1	6.202735855	1.179797784	5.257456776	3.88708477	8.518386939

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
8.689681802	365.2966014	28.60218556	264.567072
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
350.9955032	379.5976888	14.30109815	14.30108741

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	8.689681802	1.162693912	7.47374843	6.407601385	10.97176222
Ctr	365.2966014	5.412562492	67.4905097	354.6730806	375.9201221
Wid1	12.14624157	3.994558632	3.040696779	4.305911509	19.98657163

Peak# 4 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	10.2558695	1.053495109	9.735089814	8.188119313	12.32361969
Rte1	365.604939	153.822463	2.376798108	63.68951074	667.5203672

Background Order=0 Area=3397.7773342

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	5.325669803	1.276007703	4.17369722	2.821182457	7.830157149

Total Peaks= 4 Coefficient Count= 12 Fitted Count=12
Std Error for Curve= 3.16759238 r2= 0.7687606841

Source	Sum of Squares	DF	Mean Square	F
Regr	20914.891	11	1901.3537	189.498
Error	6291.0932	627	10.033641	
Total	27205.984	638		

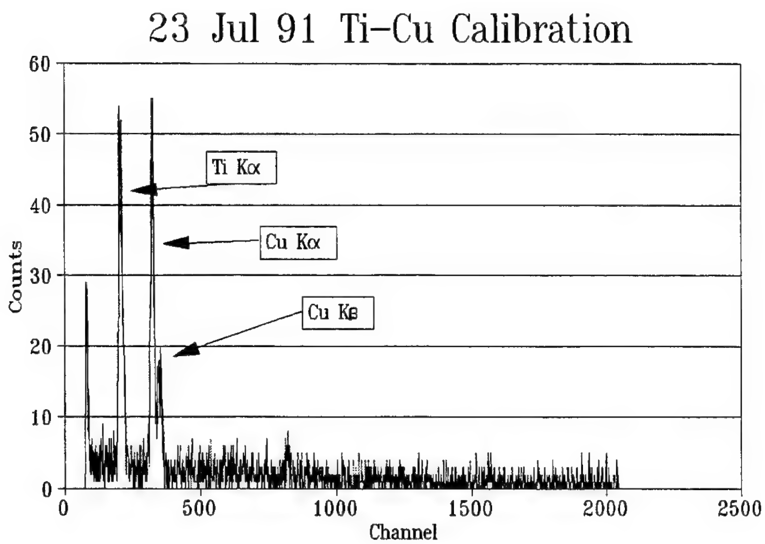
05 Sep 91 Energy Calibration Linear Regression Calculations

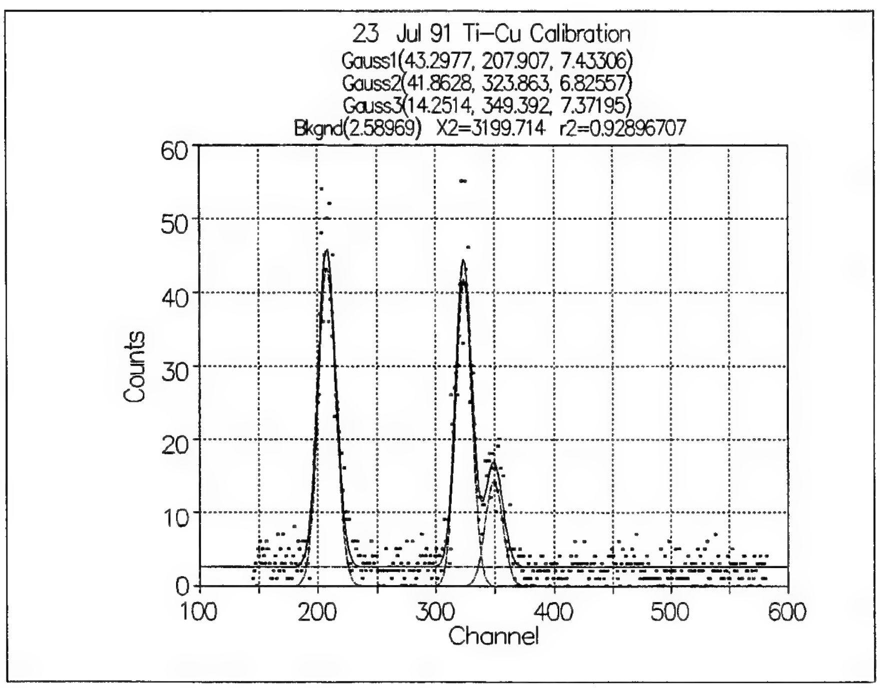
Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	235.794	4.507
Cu	Kα	346.642	8.037
Cu	Kß	365.297	8.94

Regression Output:	
Constant	-3.39068
Std Err of Y Est	0.199691
R Squared	0.996367
No. of Observations	3
Degrees of Freedom	1

X Coefficient(s)	0.033402
Std Err of Coef.	0.002017

A8. ENERGY CALIBRATION DATA TAKEN 23 JULY 1991





PeakFit Numerical Summary

Description: 23 Jul 91 Ti-Cu Calibration
X-Y Table Size: 2048 Active Points: 437
X Variable: Channel
Y Variable: Counts
File Source: CL723X1.PRN

Curve-Fit Std Error= 2.73742132 r2= 0.928967075

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	2.5896934			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	43.297681	207.90749	7.4330587		
2	Gaussian	41.862844	323.86331	6.8255688		
3	Gaussian	14.251353	349.39218	7.3719492		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	43.297681	207.90749	17.503506	806.72011	45.161377
2	Gaussian	41.862844	323.86331	16.072958	716.23827	40.096071
3	Gaussian	14.251353	349.39218	17.359569	263.34701	14.742552
	Total				1786.3054	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
43.29768119	207.9074947	17.50350623	806.7201125
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
199.1557407	216.6592469	8.751753959	8.751752272

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	43.29768119	0.9296827	46.57253621	41.47068319	45.12467919
Ctr	207.9074947	0.183099989	1135.486112	207.5476694	208.2673199
Wid1	7.433058709	0.186653889	39.82268339	7.066249386	7.799868031

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
41.86284426	323.8633121	16.07295768	716.2382678
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
315.8268211	331.8997788	8.036490964	8.036466714

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	41.86284426	0.983521115	42.56425572	39.93004384	43.79564468
Ctr	323.8633121	0.206456203	1568.678037	323.4575875	324.2690366
Wid1	6.825568808	0.219760444	31.05913275	6.393698996	7.257438619

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
14.25135341	349.3921826	17.35956898	263.3470052
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
340.7123956	358.0719645	8.679787021	8.67978196

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	14.25135341	0.95301302	14.95399655	12.37850703	16.12419979
Ctr	349.3921826	0.626970284	557.2707216	348.1600703	350.6242948
Wid1	7.371949237	0.67856483	10.86403083	6.038444173	8.705454301

Background Order=0 Area=1129.1063244

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	2.589693405	0.14931073	17.3443222	2.296270278	2.883116532

Total Peaks= 3 Coefficient Count= 10 Fitted Count=10
Std Error for Curve= 2.737421321 r2= 0.9289670749

Source	Sum of Squares	DF	Mean Square	F
Regr	41845.792	9	4649.5324	620.477
Error	3199.714	427	7.4934755	
Total	45045.506	436		

23 Jul 91 Energy Calibration Linear Regression Calculations

Element	X-Ray Line	Channel	Energy Kev
Ti	Kα	207.907	4.507
Cu	Kα	323.863	8.037
Cu	Kß	349.392	8.94

Regression Output:		
Constant		-1.96122
Std Err of Y Est		0.078996
R Squared		0.999431
No. of Observations		3
Degrees of Freedom		1
X Coefficient(s)	0.031059	
Std Err of Coef.	0.000741	

APPENDIX B. CHANNEL CONVERSION PROGRAM

The following Q-Basic program was used to convert data files taken at 8000 channel resolution to 2000 channel resolution.

```
REM QBASIC PROGRAM TO CONVERT 8K CHANNEL FILES TO 2K CHANNEL FILES
REM BY LT JOE THIEN
CLS
INPUT "File name to convert"; INFILE$
INPUT "Save as filename"; OUTFILE$
REM OPEN FILES
OPEN INFILE$ FOR INPUT AS #1
OPEN OUTFILE$ FOR OUTPUT AS #2
REM VAR LIST
REM ICHNL   - INPUT CHNL#
REM ICNTS& - INPUT COUNTS
REM IROI    - INPUT ROI
REM OCHNL   - OUTPUT CHNL#
REM OCOUNTS- OUTPUT COUNTS
REM READS AND INPUTS START OF FILE
INPUT "Number of lines"; Z
FOR Y = 1 TO Z
LINE INPUT #1, LINE$
WRITE #2, LINE$
NEXT Y
REM READS 4 RECORDS, CONVERTS TO 1
OCHNL = 0
DO
COUNTS& = 0
FOR X = 1 TO 4
INPUT #1, ICHNL, ICNTS&, IROI
COUNTS& = COUNTS& + ICNTS&
IF EOF(1) = -1 THEN EXIT FOR
NEXT X
WRITE #2, OCHNL, COUNTS&
OCHNL = OCHNL + 1
IF EOF(1) = -1 THEN EXIT DO
LOOP
REM CLOSE FILES
CLOSE
END
```

APPENDIX C. UNCORRECTED PXR DATA

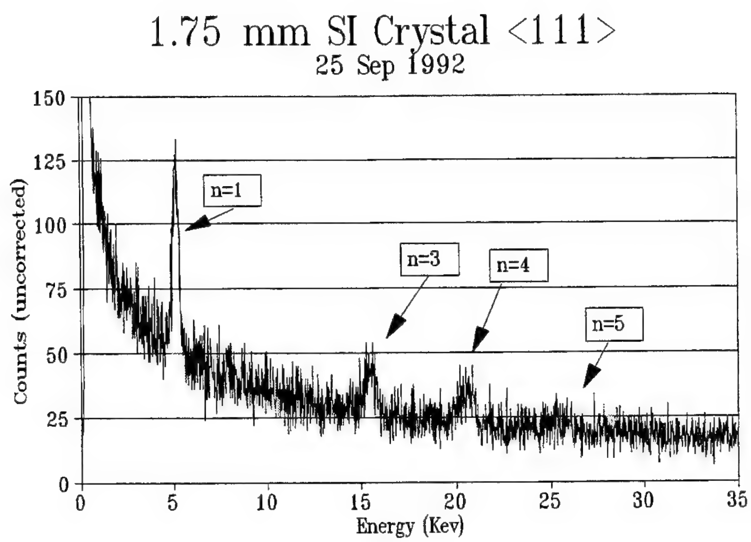
This appendix contains the uncorrected PXR spectrums and the Peakfit graphical and numerical analysis of the spectrums.

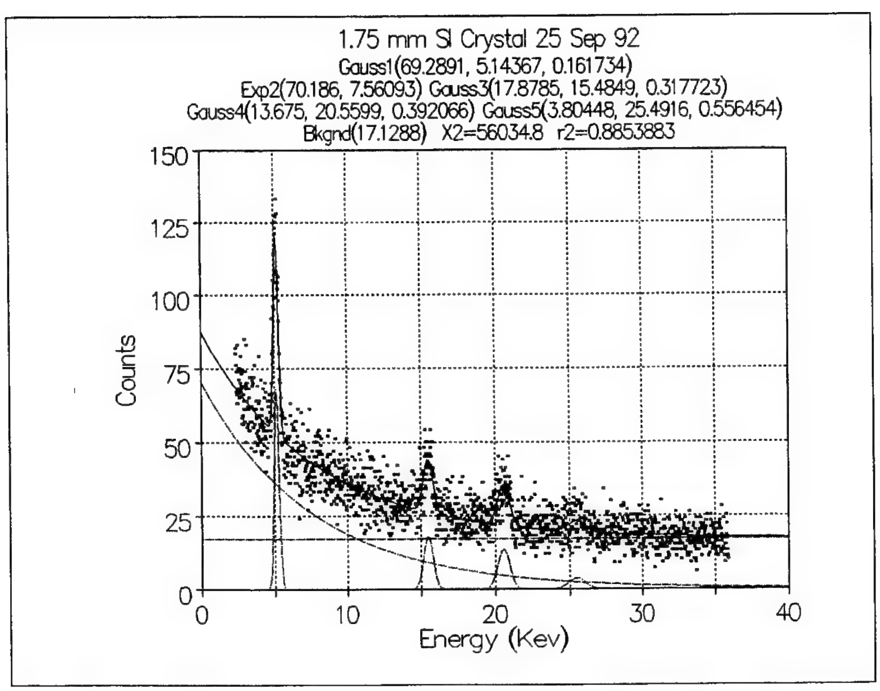
Section	Date	Beam Energy	Target
C1	25 Sep 92	96 MeV	1.75mm Si
C2	29-30 Sep 92	96 MeV	1.75mm Si
C3	02 Dec 92	91 MeV	1.75mm Si
C4	01 Dec 92	92 MeV	1mm LiF
C5	03 Dec 92	62 MeV	1mm LiF
C6	22 Oct 92	95 MeV	1mm LiF
C7	05 Sep 91	85 MeV	320μm Si
C8	05 Sep 91	85 MeV	44μm Si
C9	23 Jul 91	85 MeV	20μm Si

Table 12. Uncorrected PXR Data Runs.

Sections C7, C8 and C9 are reanalysis of PXR spectrums reported on in Reference 5.

C1. UNCORRECTED SILICON DATA TAKEN 25 SEPTEMBER 1992





PeakFit Numerical Summary

Description: 1.75 mm SI Crystal 25 Sep 92
X-Y Table Size: 2048   Active Points: 1775
X Variable: Energy (Kev)
Y Variable: Counts
File Source: SI925X04.PRN

Curve-Fit Std Error= 5.64251315   r2= 0.885388299

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	17.128839			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	69.289085	5.1436685	0.1617336		
2	Exp	70.185997	7.5609279			
3	Gaussian	17.878502	15.484855	0.3177234		
4	Gaussian	13.675019	20.559929	0.3920663		
5	Gaussian	3.8044822	25.491575	0.5564538		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	69.289085	5.1436685	0.3808533	28.090213	45.993144
2	Exp	0	0	0	0	0
3	Gaussian	17.878502	15.484855	0.7481803	14.238682	23.313521
4	Gaussian	13.675019	20.559929	0.9232448	13.439321	22.004697
5	Gaussian	3.8044822	25.491575	1.3103463	5.306567	8.6886382
	Total				61.074784	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
69.28908454	5.143668486	0.380853329	28.09021295
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.953241873	5.334095202	0.190426613	0.190426716

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	69.28908454	1.785994497	38.79579956	65.79545013	72.78271894
Ctr	5.143668486	0.004780212	1076.033504	5.134317778	5.153019194
Wid1	0.161733562	0.004883798	33.11634693	0.152180226	0.171286898

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	70.18599676	1.181284709	59.41497102	67.8752523	72.49674123
Rte1	7.560927878	0.203922893	37.07738638	7.162028535	7.959827222

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
17.87850231	15.48485504	0.74818031	14.23868246
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.11076439	15.8589447	0.374090646	0.374089664

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	17.87850231	1.273999755	14.03336401	15.38639532	20.3706093
Ctr	15.48485504	0.025960459	596.4784727	15.43407305	15.53563703
Wid1	0.317723383	0.026506607	11.98657308	0.265873059	0.369573708

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
13.67501875	20.55992924	0.92324478	13.4393212
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
20.09830648	21.02155126	0.461622763	0.461622018

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	13.67501875	1.145856347	11.93432212	11.43357671	15.91646079
Ctr	20.55992924	0.037705104	545.2823842	20.48617322	20.63368526
Wid1	0.392066311	0.038399389	10.21022263	0.316952179	0.467180444

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
3.804482152	25.49157521	1.310346262	5.306566959
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
24.83640287	26.14674913	0.655172345	0.655173917

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	3.804482152	0.965946217	3.938606608	1.91496741	5.693996895
Ctr	25.49157521	0.161479801	157.8623155	25.1757	25.80745042
Widl	0.556453797	0.166461166	3.342844515	0.230834397	0.882073198

Background Order=0 Area=573.3639917

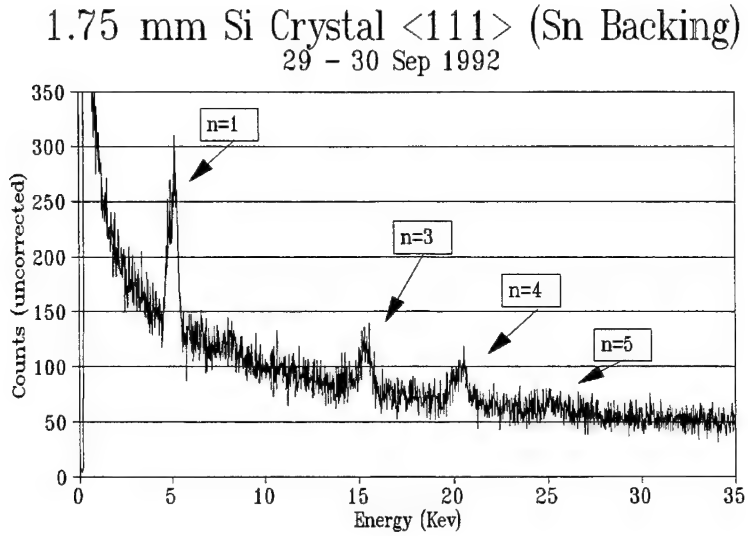
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	17.12883852	0.318250714	53.82183847	16.50629928	17.75137775

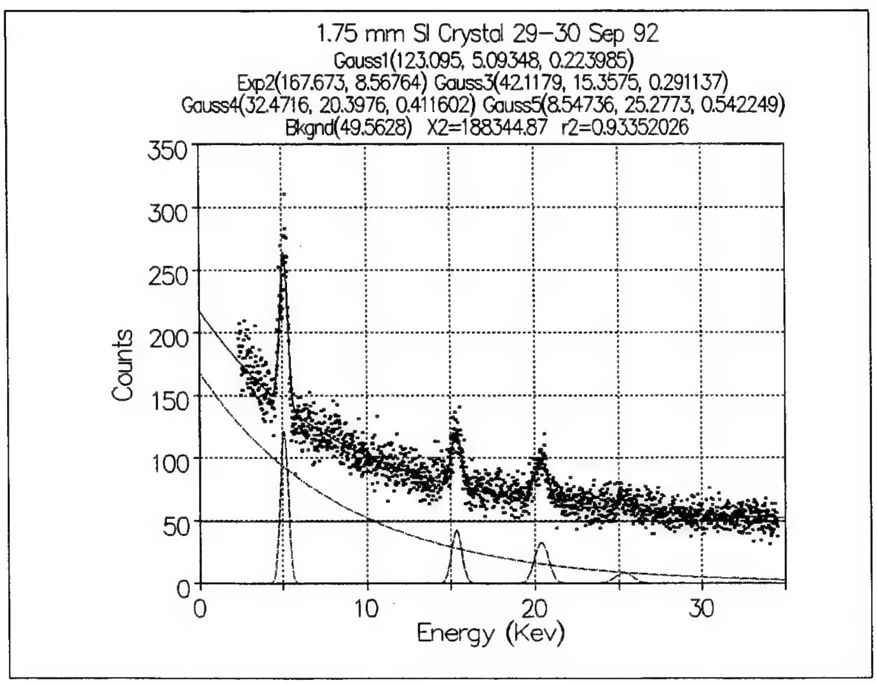
Total Peaks= 5 Coefficient Count= 15 Fitted Count=15

Std Error for Curve= 5.64251315 r2= 0.8853882992

Source	Sum of Squares	DF	Mean Square	F
Regr	432875.14	14	30919.653	971.157
Error	56034.8	1760	31.837955	
Total	488909.94	1774		

C2. UNCORRECTED SILICON DATA TAKEN 29-30 SEPTEMBER 1992





PeakFit Numerical Summary

Description: 1.75 mm SI Crystal 29-30 Sep 92
X-Y Table Size: 2048 Active Points: 1791
X Variable: Energy (Kev)
Y Variable: Counts
File Source: SI930X13.PRN

Curve-Fit Std Error= 10.29806 r2= 0.93352026

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	49.562824			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	123.09458	5.0934798	0.2239853		
2	Exp	167.67315	8.5676361			
3	Gaussian	42.117852	15.357468	0.2911374		
4	Gaussian	32.471577	20.397633	0.4116021		
5	Gaussian	8.547362	25.277285	0.5422488		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	123.09458	5.0934798	0.5274446	69.111174	47.673614
2	Exp	0	0	0	0	0
3	Gaussian	42.117852	15.357468	0.6855745	30.736466	21.202337
4	Gaussian	32.471577	20.397633	0.9692467	33.502017	23.110043
5	Gaussian	8.547362	25.277285	1.2768967	11.617692	8.0140058
	Total				144.96735	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
123.094581	5.0934798	0.527444615	69.11117386
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.829757501	5.357202116	0.263722298	0.263722316

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	123.094581	2.712163459	45.38612175	117.7894382	128.3997237
Ctr	5.0934798	0.005641453	902.8666291	5.082444803	5.104514796
Wid1	0.223985252	0.005822164	38.47113627	0.212596776	0.235373728

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	167.6731534	1.87937356	89.21757596	163.9969941	171.3493127
Rte1	8.567636076	0.181182652	47.28728717	8.213232723	8.922039429

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
42.11785188	15.35746838	0.685574503	30.73646567
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.01468102	15.70025553	0.342787355	0.342787148

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	42.11785188	2.369855818	17.77232672	37.48228197	46.75342179
Ctr	15.35746838	0.018783992	817.5827876	15.32072585	15.39421091
Wid1	0.291137382	0.019176836	15.18172161	0.253626424	0.32864834

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
32.47157732	20.39763302	0.969246728	33.50201693
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
19.91300908	20.88225581	0.484623932	0.484622796

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	32.47157732	1.993301778	16.29034684	28.57256807	36.37058656
Ctr	20.39763302	0.028973919	703.9998031	20.34095842	20.45430761
Wid1	0.41160211	0.029585164	13.91244974	0.353731882	0.469472339

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
8.547361993	25.27728453	1.276896658	11.61769169
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
24.63883571	25.91573237	0.638448822	0.638447835

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	8.547361993	1.743721238	4.901793822	5.136546177	11.95817781
Ctr	25.27728453	0.12635793	200.0450986	25.03012139	25.52444768
Wid1	0.542248768	0.130514054	4.154715545	0.286956013	0.797541522

Background Order=0 Area=1593.631644

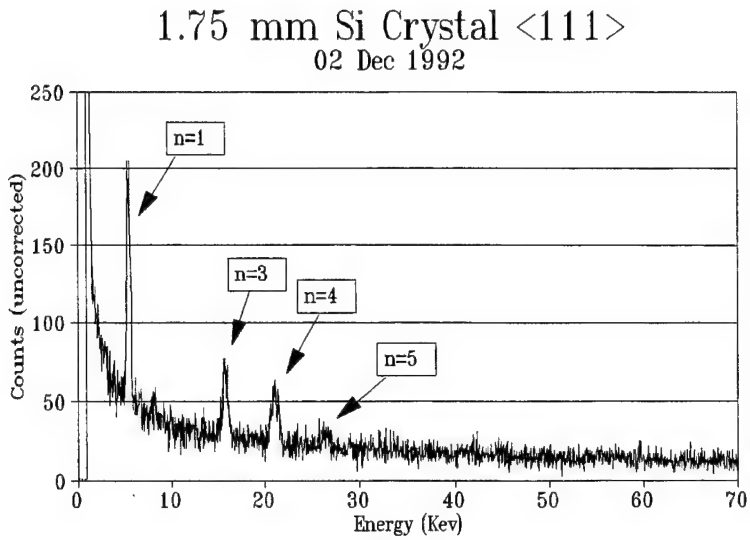
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	49.56282402	0.702083116	70.59395517	48.18951036	50.93613768

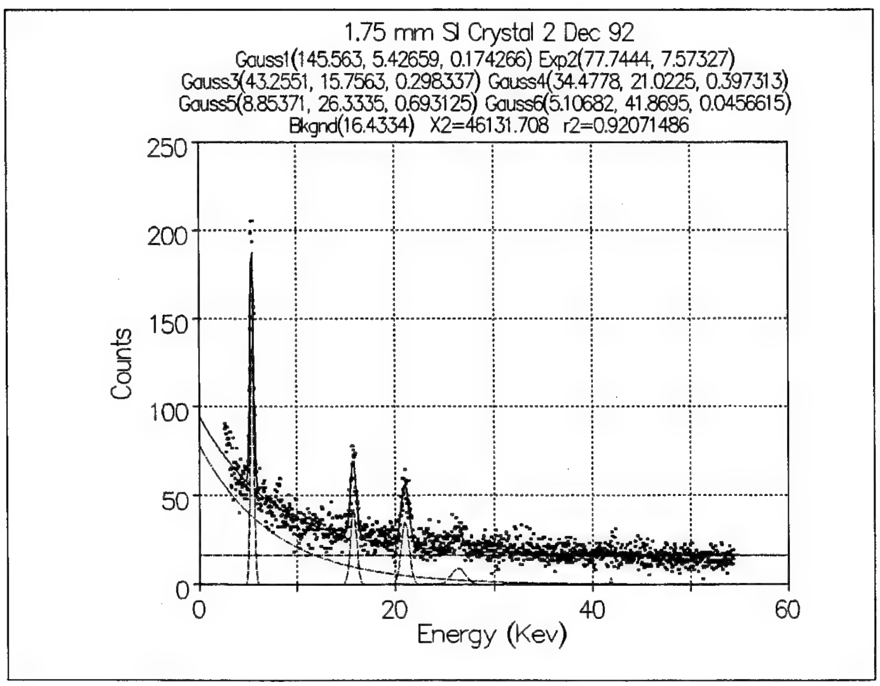
Total Peaks= 5 Coefficient Count= 15 Fitted Count=15

Std Error for Curve= 10.29805997 r2= 0.9335202603

Source	Sum of Squares	DF	Mean Square	F
Regr	2644772	14	188912.28	1781.35
Error	188344.87	1776	106.05004	
Total	2833116.8	1790		

C3. UNCORRECTED SILICON DATA TAKEN 02 DECEMBER 1992





PeakFit Numerical Summary

Description: 1.75 mm SI Crystal 2 Dec 92
X-Y Table Size: 2048 Active Points: 1396
X Variable: Energy (Kev)
Y Variable: Counts
File Source: SI1202Y2.PRN

Curve-Fit Std Error= 5.78595643 r2= 0.920714858

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	16.433363			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	145.56285	5.426595	0.1742659		
2	Exp	77.744373	7.5732685			
3	Gaussian	43.255097	15.756303	0.2983369		
4	Gaussian	34.47776	21.02249	0.3973126		
5	Gaussian	8.8537085	26.333534	0.6931246		
6	Gaussian	5.1068174	41.869497	0.0456615		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	145.56285	5.426595	0.4103644	63.584731	43.481004
2	Exp	0	0	0	0	0
3	Gaussian	43.255097	15.756303	0.7025279	32.34701	22.119783
4	Gaussian	34.47776	21.02249	0.9355975	34.336921	23.48054
5	Gaussian	8.8537085	26.333534	1.6321822	15.382483	10.518969
6	Gaussian	5.1068174	41.869497	0.1075225	0.5845097	0.399704
	Total				146.23566	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
145.5628498	5.426594993	0.410364367	63.58473089
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
5.221412762	5.631777129	0.205182231	0.205182136

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	145.5628498	2.474366859	58.8283218	140.7181839	150.4075158
Ctr	5.426594993	0.003395483	1598.18039	5.419946834	5.433243151
Wid1	0.174265864	0.003472925	50.17841693	0.16746608	0.181065648

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	77.74437278	1.759237634	44.19208144	74.29988813	81.18885743
Rtel	7.573268508	0.21460257	35.28973811	7.153089195	7.993447821

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
43.25509678	15.75630278	0.702527943	32.34700976
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.40503887	16.10756681	0.351263912	0.351264031

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	43.25509678	1.889029181	22.89805643	39.55648785	46.95370571
Ctr	15.75630278	0.014946355	1054.190311	15.72703869	15.78556687
Wid1	0.298336869	0.015238616	19.57768812	0.268500548	0.328173189

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
34.47776004	21.02249016	0.935597543	34.33692129
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
20.55469095	21.49028849	0.467799211	0.467798332

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	34.47776004	1.634364023	21.09552067	31.27777063	37.67774945
Ctr	21.02249016	0.021640471	971.4432743	20.98011938	21.06486094
Wid1	0.397312632	0.021964	18.08926593	0.354308402	0.440316862

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
8.853708454	26.333534	1.632182218	15.38248342
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
25.51744316	27.14962538	0.81609084	0.816091378

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	8.853708454	1.238674852	7.147726005	6.428455358	11.27896155
Ctr	26.333534	0.111327023	236.5421552	26.11556218	26.55150582
Wid1	0.693124607	0.113315195	6.116784329	0.471260067	0.914989147

Peak# 6 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
5.106817443	41.86949672	0.107522452	0.584509726
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
41.815735	41.92325745	0.053761723	0.053760729

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	5.106817443	4.79920509	1.064096522	-4.28974614	14.50338102
Ctr	41.86949672	0.049525618	845.4108959	41.77252845	41.96646499
Wid1	0.045661489	0.049598458	0.920623161	-0.0514494	0.142772376

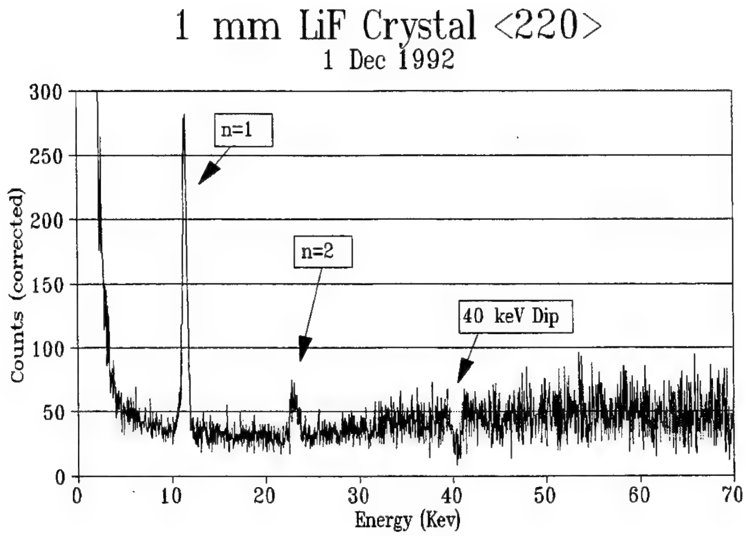
Background Order=0 Area=850.15662478

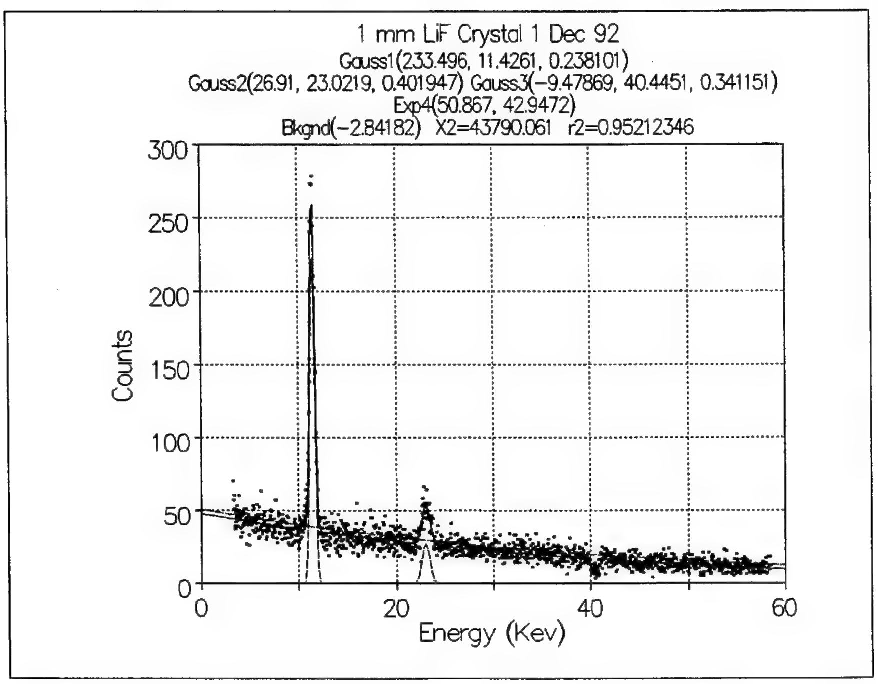
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	16.43336315	0.244136373	67.3122279	15.95535837	16.91136792

Total Peaks= 6 Coefficient Count= 18 Fitted Count=18
Std Error for Curve= 5.78595643 r2= 0.9207148577

Source	Sum of Squares	DF	Mean Square	F
Regr	535713.85	17	31512.58	941.312
Error	46131.708	1378	33.477292	
Total	581845.56	1395		

C4. UNCORRECTED LITHIUM FLUORIDE DATA TAKEN 01 DECEMBER 1992





PeakFit Numerical Summary

Description: 1 mm LiF Crystal 1 Dec 92
X-Y Table Size: 2048 Active Points: 1498
X Variable: Energy (Kev)
Y Variable: Counts
File Source: LI1201Y1.PRN

Curve-Fit Std Error= 5.4284816 r2= 0.952123457

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	-2.841825			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	233.49555	11.426061	0.2381008		
2	Gaussian	26.909961	23.021917	0.4019469		
3	Gaussian	-9.47869	40.445122	0.3411507		
4	Exp	50.866994	42.94722			

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	233.49555	11.426061	0.5606838	139.3572	87.997893
2	Gaussian	26.909961	23.021917	0.9465112	27.112637	17.120428
3	Gaussian	-9.47869	40.445122	0.8033495	-8.10559	-5.11832
4	Exp	0	0	0	0	0
	Total				158.36425	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
233.4955514	11.42606142	0.560683799	139.3572032
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
11.14571978	11.70640358	0.280341639	0.28034216

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	233.4955514	1.971721065	118.4222026	229.6360836	237.3550192
Ctr	11.42606142	0.002313156	4939.598856	11.42153362	11.43058922
Wid1	0.238100811	0.002338781	101.8055192	0.233522856	0.242678766

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
26.90996134	23.02191677	0.946511158	27.11263692
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
22.54866172	23.49517288	0.473255048	0.47325611

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	26.90996134	1.520472299	17.69842263	23.9337727	29.88614999
Ctr	23.02191677	0.026077538	882.8255452	22.97087232	23.07296122
Wid1	0.401946949	0.026513962	15.15982217	0.350048238	0.45384566

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
-9.47869001	40.44512226	0.803349497	-8.10558974
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
40.04344737	40.84679686	0.401674898	0.401674599

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	-9.47869001	1.646389334	-5.75725912	-12.70135	-6.25603002
Ctr	40.44512226	0.068205953	592.985219	40.3116152	40.57862932
Wid1	0.341150747	0.068857413	4.954451984	0.206368514	0.475932979

Peak# 4 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	50.86699418	1.991728576	25.53911953	46.96836348	54.76562488
Rtel	42.94721964	3.992538856	10.75686955	35.13218162	50.76225766

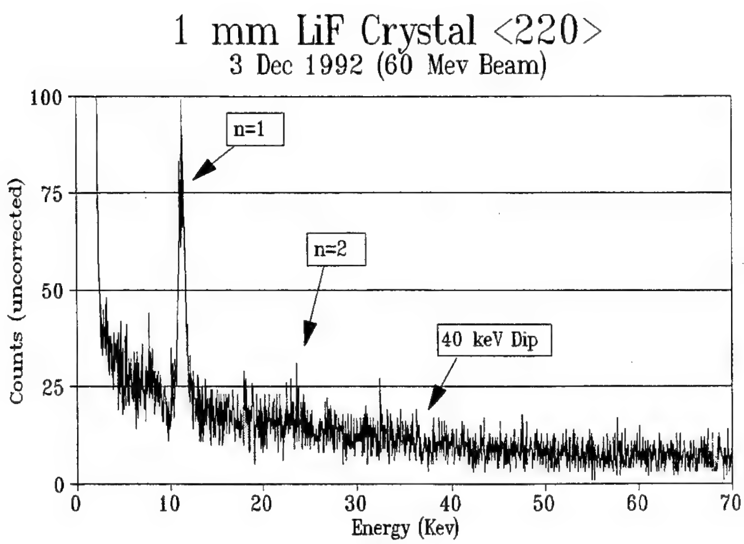
Background Order=0 Area=-156.73790888

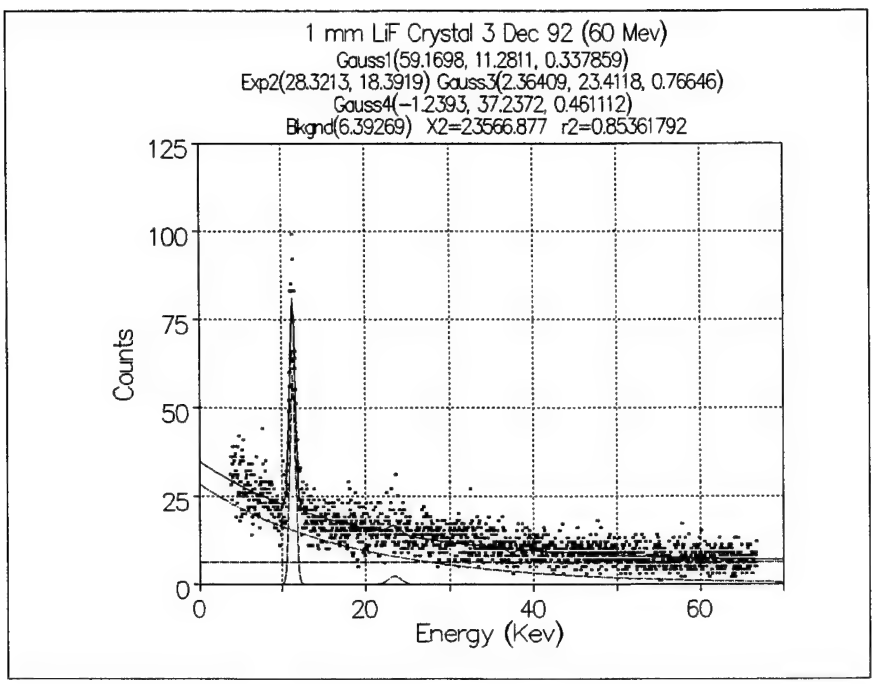
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	-2.84182455	2.431695144	-1.16865988	-7.60165049	1.918001386

Total Peaks= 4 Coefficient Count= 12 Fitted Count=12
Std Error for Curve= 5.428481597 r2= 0.9521234568

Source	Sum of Squares	DF	Mean Square	F
Regr	870855.36	11	79168.669	2686.56
Error	43790.061	1486	29.468412	
Total	914645.42	1497		

C5. UNCORRECTED LITHIUM FLUORIDE DATA TAKEN 03 DECEMBER 1992





PeakFit Numerical Summary

Description: 1 mm LiF Crystal 3 Dec 92 (60 Mev)
X-Y Table Size: 2048   Active Points: 1667
X Variable: Energy (Kev)
Y Variable: Counts
File Source: LI1203Y1.PRN

Curve-Fit Std Error= 3.77356661   r2= 0.853617919

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	6.3926869			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	59.169762	11.281125	0.3378593		
2	Exp	28.321278	18.391933			
3	Gaussian	2.3640929	23.41183	0.7664595		
4	Gaussian	-1.239303	37.237172	0.4611117		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	59.169762	11.281125	0.7955972	50.110143	94.157171
2	Exp	0	0	0	0	0
3	Gaussian	2.3640929	23.41183	1.804873	4.5419649	8.5343713
4	Gaussian	-1.239303	37.237172	1.0858393	-1.43243	-2.691542
	Total				53.219678	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
59.16976176	11.28112538	0.795597168	50.11014312
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
10.88332659	11.67892376	0.397798792	0.397798376

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	59.16976176	1.168113747	50.6541096	56.8842181	61.45530543
Ctr	11.28112538	0.007657743	1473.165765	11.26614216	11.29610861
Wid1	0.337859319	0.007792016	43.35968226	0.322613379	0.353105258

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	28.32127825	0.545645665	51.90415699	27.25366219	29.3888943
Rte1	18.3919328	0.876332229	20.98739746	16.67729193	20.10657367

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
2.364092937	23.41183023	1.804872965	4.541964928
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
22.50939428	24.31426724	0.902435952	0.902437014

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	2.364092937	0.780792402	3.027812428	0.8363863	3.891799575
Ctr	23.41183023	0.288663896	81.10411631	22.84702741	23.97663305
Wid1	0.766459549	0.299294967	2.560883522	0.180855864	1.352063233

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
-1.23930261	37.23717224	1.085839348	-1.43243013
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
36.69425308	37.78009242	0.542919166	0.542920183

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	-1.23930261	0.997901903	-1.24190825	-3.19180798	0.713202768
Ctr	37.23717224	0.427065181	87.19318254	36.40157201	38.07277247
Wid1	0.461111693	0.432077956	1.067195599	-0.38429659	1.306519973

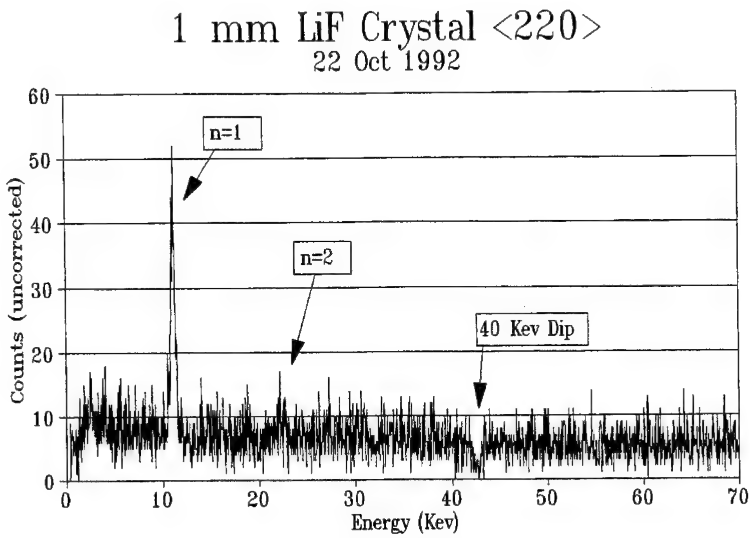
Background Order=0 Area=402.620783

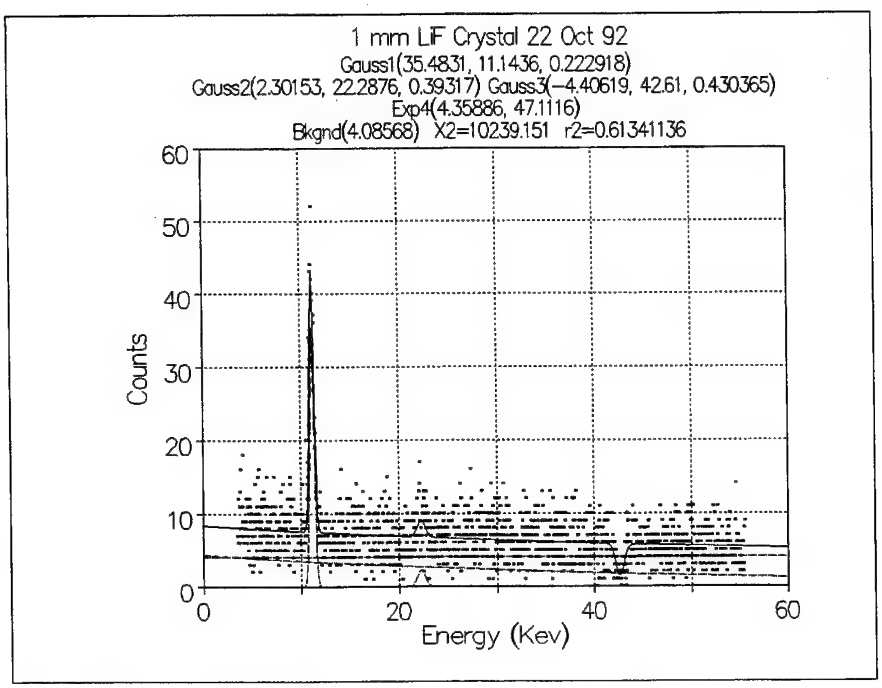
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	6.39268695	0.293850959	21.75486159	5.817735067	6.967638832

Total Peaks= 4 Coefficient Count= 12 Fitted Count=12
Std Error for Curve= 3.773566612 r2= 0.8536179186

Source	Sum of Squares	DF	Mean Square	F
Regr	137428.77	11	12493.524	877.366
Error	23566.877	1655	14.239805	
Total	160995.64	1666		

C6. UNCORRECTED LITHIUM FLUORIDE DATA TAKEN 22 OCTOBER 1992





PeakFit Numerical Summary

Description: 1 mm LiF Crystal 22 Oct 92
X-Y Table Size: 2048   Active Points: 1436
X Variable: Energy (Kev)
Y Variable: Counts
File Source: LI1022X1.PRN

Curve-Fit Std Error= 2.68149496   r2= 0.613411356

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	4.0856779			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	35.483102	11.143649	0.2229178		
2	Gaussian	2.3015343	22.287562	0.3931702		
3	Gaussian	-4.406189	42.610002	0.4303655		
4	Exp	4.3588578	47.111575			

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	35.483102	11.143649	0.5249303	19.826939	114.32948
2	Gaussian	2.3015343	22.287562	0.9258436	2.2682345	13.079481
3	Gaussian	-4.406189	42.610002	1.0134372	-4.753242	-27.40896
4	Exp	0	0	0	0	0
	Total				17.341931	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
35.48310234	11.14364903	0.524930314	19.82693859
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
10.88118411	11.40611442	0.262464928	0.262465386

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	35.48310234	0.997856916	35.55930892	33.52958459	37.4366201
Ctr	11.14364903	0.007212137	1545.124357	11.12952974	11.15776833
Wid1	0.222917816	0.007292225	30.56924425	0.20864173	0.237193903

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
2.301534314	22.28756195	0.925843583	2.268234491
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
21.82463978	22.75048336	0.462922168	0.462921415

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	2.301534314	0.752848134	3.057103034	0.827673509	3.77539512
Ctr	22.28756195	0.147666252	150.9319951	21.99847376	22.57665013
Wid1	0.393170164	0.150159771	2.618345515	0.099200382	0.687139946

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
-4.4061889	42.61000214	1.013437155	-4.75324235
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
42.10328239	43.11671955	0.506719749	0.506717407

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	-4.4061889	0.718930303	-6.12881232	-5.81364832	-2.99872948
Ctr	42.61000214	0.080704127	527.9779838	42.4520066	42.76799768
Wid1	0.430365488	0.08185176	5.257864804	0.270123209	0.590607768

Peak# 4 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	4.35885776	1.408594619	3.094472818	1.601233338	7.116482182
Rte1	47.11157452	31.93451055	1.475255882	-15.4070415	109.6301906

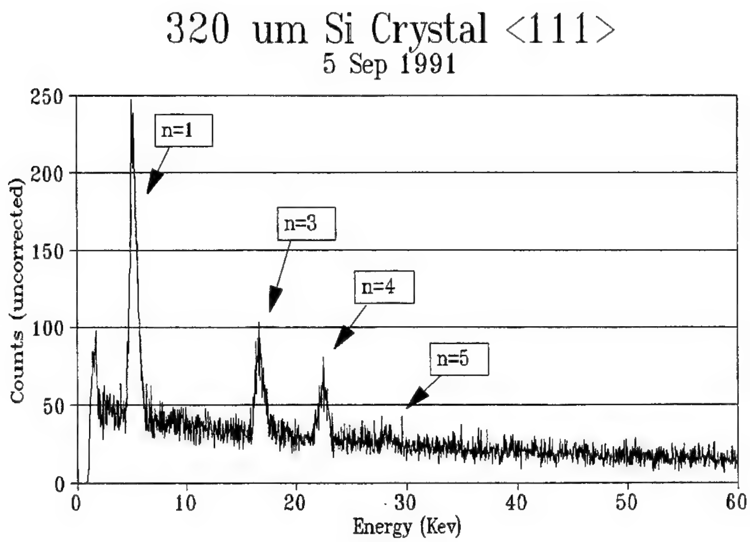
Background Order=0 Area=212.2738892

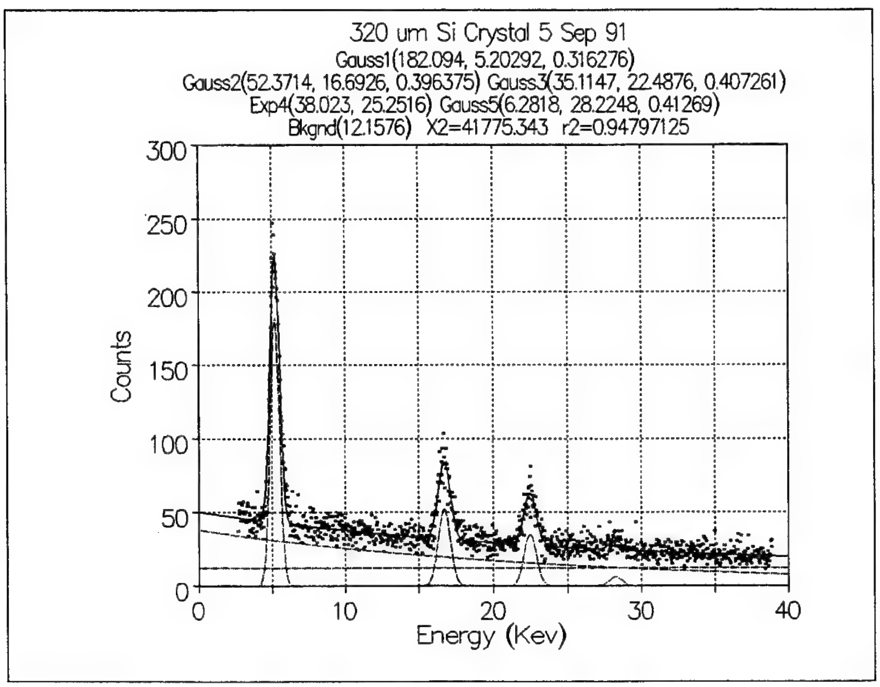
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	4.085677932	1.647034452	2.480626879	0.861256678	7.310099185

Total Peaks= 4 Coefficient Count= 12 Fitted Count=12
Std Error for Curve= 2.681494961 r2= 0.6134113562

Source	Sum of Squares	DF	Mean Square	F
Regr	16246.757	11	1476.9779	205.409
Error	10239.151	1424	7.1904152	
Total	26485.908	1435		

C7. UNCORRECTED SILICON DATA TAKEN 05 SEPTEMBER 1991





PeakFit Numerical Summary

Description: 320 um Si Crystal 5 Sep 91
X-Y Table Size: 2048   Active Points: 1084
X Variable: Energy (Kev)
Y Variable: Counts
File Source: SI905T32.PRN

Curve-Fit Std Error= 6.2513118   r2= 0.947971247

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	12.157602			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	182.094	5.202924	0.3162762		
2	Gaussian	52.371441	16.692642	0.3963745		
3	Gaussian	35.114699	22.48765	0.4072609		
4	Exp	38.022988	25.251564			
5	Gaussian	6.2818032	28.22476	0.4126904		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	182.094	5.202924	0.7447733	144.362	60.467909
2	Gaussian	52.371441	16.692642	0.9333896	52.034345	21.795265
3	Gaussian	35.114699	22.48765	0.9590236	35.846887	15.014937
4	Exp	0	0	0	0	0
5	Gaussian	6.2818032	28.22476	0.9718108	6.4982816	2.7218901
	Total				238.74152	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
182.0940009	5.202924042	0.744773253	144.3620016
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.830537339	5.575310592	0.372386703	0.37238655

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	182.0940009	1.904302369	95.62241996	178.362345	185.8256567
Ctr	5.202924042	0.003751938	1386.72984	5.195571775	5.21027631
Wid1	0.316276178	0.003959931	79.86910943	0.308516328	0.324036028

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
52.37144131	16.69264198	0.933389608	52.03434479
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
16.22594727	17.15933688	0.466694708	0.4666949

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	52.37144131	1.686750444	31.04871945	49.06609851	55.67678412
Ctr	16.69264198	0.014590911	1144.043864	16.66404975	16.72123421
Wid1	0.396374507	0.015033304	26.36642724	0.366915364	0.42583365

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
35.1146993	22.48764954	0.959023613	35.8468872
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
22.00813721	22.96716083	0.479512332	0.479511281

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	35.1146993	1.66200011	21.12797652	31.85785705	38.37154155
Ctr	22.48764954	0.022058849	1019.438924	22.4444232	22.53087589
Wid1	0.407260854	0.022649663	17.9808795	0.362876755	0.451644954

Peak# 4 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	38.02298816	2.095543296	18.14469223	33.91657812	42.1293982
Rtel	25.25156386	4.147520103	6.088352373	17.12411633	33.37901139

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
6.281803185	28.22475999	0.97181083	6.498281647
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
27.73885495	28.71066578	0.485905045	0.485905785

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	6.281803185	1.647658865	3.812562976	3.053063929	9.51054244
Ctr	28.22475999	0.124141769	227.3590934	27.98149277	28.46802722
Wid1	0.412690383	0.126719299	3.256728749	0.16437225	0.661008517

Background Order=0 Area=439.79355138

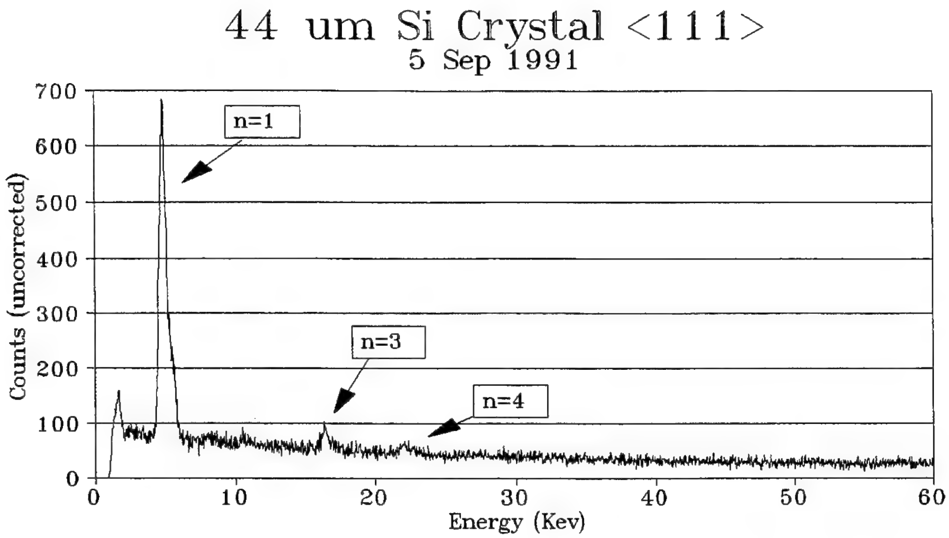
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	12.15760219	2.853783892	4.260169183	6.565349891	17.74985449

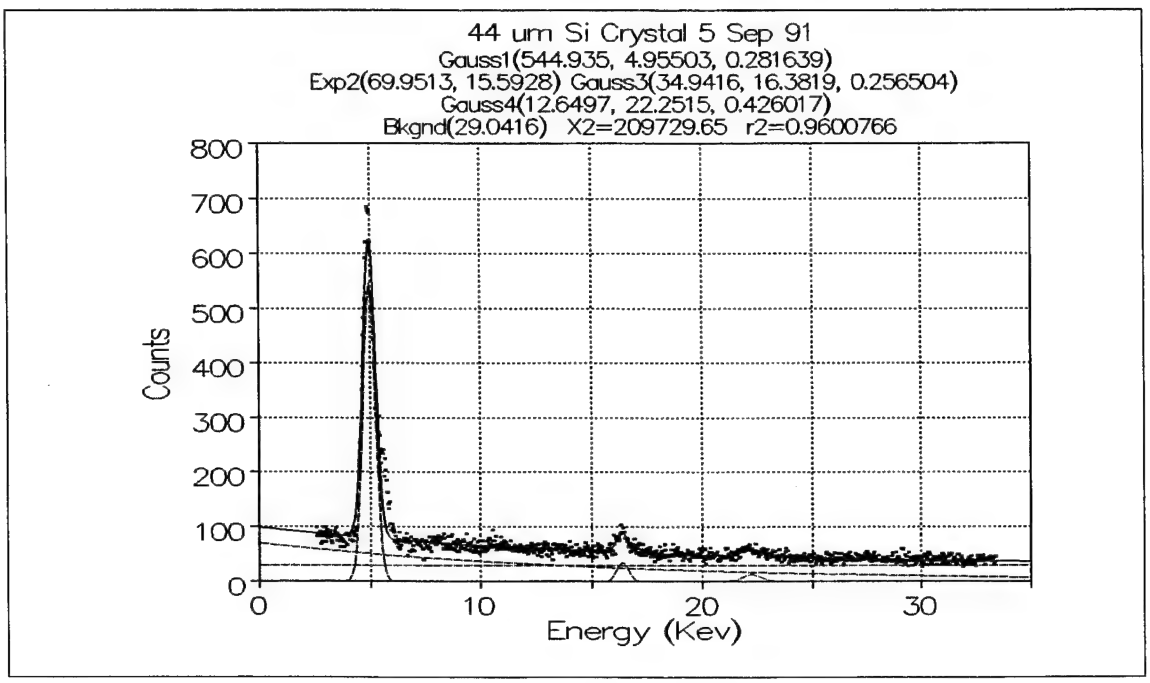
Total Peaks= 5 Coefficient Count= 15 Fitted Count=15

Std Error for Curve= 6.251311796 r2= 0.9479712474

Source	Sum of Squares	DF	Mean Square	F
Regr	761152.67	14	54368.048	1391.24
Error	41775.343	1069	39.078899	
Total	802928.02	1083		

C8. UNCORRECTED SILICON DATA TAKEN 05 SEPTEMBER 1991





PeakFit Numerical Summary

Description: 44 um Si Crystal 5 Sep 91
X-Y Table Size: 2048   Active Points: 923
X Variable: Energy (Kev)
Y Variable: Counts
File Source: SI905T44.PRN

Curve-Fit Std Error= 15.1729743   r2= 0.960076604

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	29.041573			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	544.93525	4.9550302	0.2816395		
2	Exp	69.951318	15.592822			
3	Gaussian	34.941649	16.381926	0.2565041		
4	Gaussian	12.649703	22.251488	0.4260173		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	544.93525	4.9550302	0.6632101	384.70494	91.448514
2	Exp	0	0	0	0	0
3	Gaussian	34.941649	16.381926	0.6040203	22.466128	5.340441
4	Gaussian	12.649703	22.251488	1.0031935	13.5082	3.2110448
	Total				420.67927	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
544.9352515	4.955030226	0.663210116	384.7049424
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.623425247	5.286635363	0.331604979	0.331605137

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	544.9352515	4.893621026	111.3562429	535.3410223	554.5294806
Ctr	4.955030226	0.002872255	1725.136103	4.949399003	4.960661448
Wid1	0.281639493	0.003023659	93.14526963	0.275711434	0.287567552

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	69.95131838	2.792742189	25.04753882	64.47598458	75.42665217
Rte1	15.59282176	2.494084958	6.251920854	10.70302287	20.48262066

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
34.94164852	16.3819261	0.604020341	22.4661281
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
16.07991568	16.68393602	0.302010419	0.302009922

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	34.94164852	5.070183174	6.891594902	25.00125896	44.88203808
Ctr	16.3819261	0.042697596	383.6732662	16.29821498	16.46563723
Wid1	0.25650409	0.04352993	5.892591436	0.171161127	0.341847054

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
12.649703	22.25148775	1.003193512	13.50819971
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
21.7498909	22.75308441	0.501596852	0.50159666

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	12.649703	3.938357767	3.211923282	4.928323109	20.3710829
Ctr	22.25148775	0.152039024	146.3537922	21.95340638	22.54956911
Wid1	0.426017297	0.155433074	2.740840719	0.121281699	0.730752895

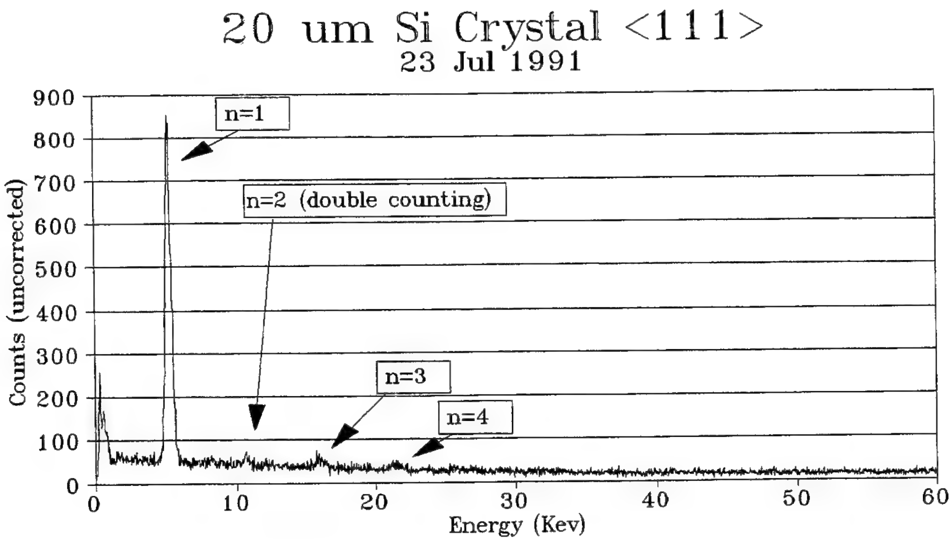
Background Order=0 Area=894.38298495

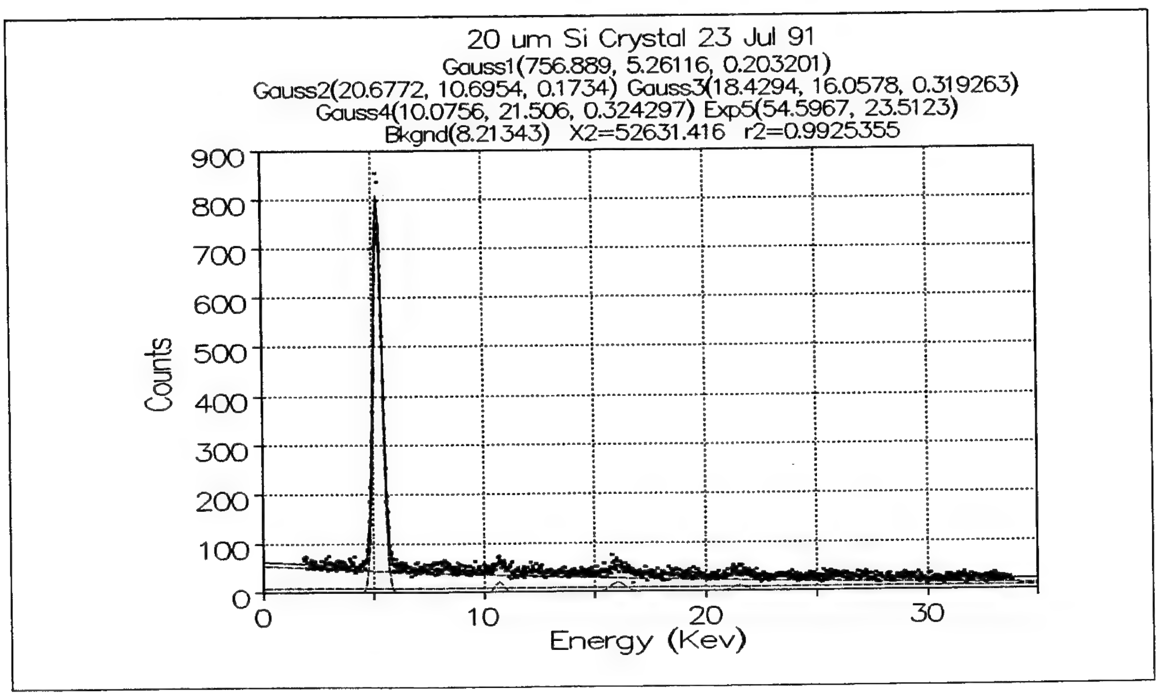
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	29.041573	3.917369027	7.413540262	21.36134276	36.72180325

Total Peaks= 4 Coefficient Count= 12 Fitted Count=12
Std Error for Curve= 15.17297435 r2= 0.9600766039

Source	Sum of Squares	DF	Mean Square	F
Regr	5043572.1	11	458506.55	1991.61
Error	209729.65	911	230.21915	
Total	5253301.7	922		

C9. UNCORRECTED SILICON DATA TAKEN 23 JULY 1991





PeakFit Numerical Summary

Description: 20 um Si Crystal 23 Jul 91
X-Y Table Size: 2048   Active Points: 1032
X Variable: Energy (Kev)
Y Variable: Counts
File Source: SI723T20.PRN

Curve-Fit Std Error= 7.19386114   r2= 0.992535502

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	8.2134311			

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	756.8885	5.2611648	0.2032013		
2	Gaussian	20.677221	10.695353	0.1733997		
3	Gaussian	18.429441	16.057834	0.3192633		
4	Gaussian	10.075559	21.506047	0.3242974		
5	Exp	54.59671	23.512274			

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	756.8885	5.2611648	0.4785021	385.52123	92.352023
2	Gaussian	20.677221	10.695353	0.4083242	8.9873248	2.1529233
3	Gaussian	18.429441	16.057834	0.751806	14.748615	3.5330465
4	Gaussian	10.075559	21.506047	0.76366	8.1903513	1.9620074
5	Exp	0	0	0	0	0
	Total				417.44752	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
756.8885017	5.261164776	0.478502097	385.5212293
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
5.021913678	5.500415775	0.239251098	0.239250999

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	756.8885017	2.608136165	290.2028321	751.7768216	762.0001817
Ctr	5.261164776	0.000802261	6557.924037	5.259592428	5.262737125
Wid1	0.203201274	0.00082136	247.395967	0.201591491	0.204811056

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
20.67722138	10.69535277	0.408324218	8.987324808
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
10.49119091	10.89951513	0.204161867	0.204162351

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	20.67722138	2.813280684	7.349860787	15.16347907	26.19096369
Ctr	10.69535277	0.027122363	394.3370584	10.64219572	10.74850983
Wid1	0.17339969	0.027479902	6.310054865	0.119541893	0.227257486

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
18.42944062	16.05783379	0.751805995	14.74861512
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.68193073	16.43373672	0.375903058	0.375902936

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	18.42944062	2.082379474	8.850183578	14.34818991	22.51069134
Ctr	16.05783379	0.041292185	388.8831225	15.97690533	16.13876225
Wid1	0.319263303	0.042364096	7.536176396	0.236234008	0.402292597

```
Peak# 4  Gaussian
  PkAmpl         PkCtr          Wid@HM         Area
  10.07555931    21.50604701    0.763659952    8.190351324
  XL @HM         XR @HM         Ctr-XL@HM      Ctr-XR@HM
  21.12421788    21.88787783    0.38182913     0.381830823
 Parm  Value          Std Error      t-value        95% Confidence Limits
 Ampl  10.07555931    2.061223608    4.888144727    6.035771925    14.1153467
  Ctr  21.50604701    0.076126668    282.503459     21.35684653    21.65524749
 Wid1  0.324297396    0.077567273    4.180853398    0.172273477    0.476321315

Peak# 5  Exp
  PkAmpl         PkCtr          Wid@HM         Area
  0              0              0              0
  XL @HM         XR @HM         Ctr-XL@HM      Ctr-XR@HM
  0              0              0              0
 Parm  Value          Std Error      t-value        95% Confidence Limits
 Ampl  54.59670971    2.868483876    19.03329845    48.97477479    60.21864463
 Rte1  23.51227448    3.143771039    7.47900346     17.35080489    29.67374407

Background  Order=0     Area=263.00908591
 Parm     Value          Std Error      t-value        95% Confidence Limits
  a       8.213431091    3.590901286    2.287289579    1.175631959    15.25123022

Total Peaks= 5   Coefficient Count= 15   Fitted Count=15
Std Error for Curve= 7.193861135     r2= 0.9925355017
Source    Sum of Squares     DF      Mean Square         F
Regr      6998266.6          14      499876.18           9659.14
Error     52631.416          1017    51.751638
Total     7050898            1031
```

APPENDIX D. ATTENUATION COEFFICIENT PROGRAMS

Attenuation coefficients were used to correct the PXR spectrums. These attenuation coefficients were calculated by XCOM running on a personal computer [Ref. 16]. Running XCOM manually for each energy channel of each data file would have been very tedious so various QBasic and MS-DOS command files were written to speed up the process.

The first step in the process is to generate energy list files to tell XCOM at what energies to calculate coefficients. This is accomplished by the following program ENLIST.BAS:

ENLIST.BAS

```
REM QBASIC PROGRAM TO SAVE ENERGY GRID FOR XCOM
REM BY LT JOE THIEN
CLS
DIM E(2050)
INPUT "File name to save"; INFILE$
REM OPEN FILES
OPEN "C:\THESIS\COR\" + INFILE$ + "1.XCM" FOR OUTPUT AS #1
OPEN "C:\THESIS\COR\" + INFILE$ + "2.XCM" FOR OUTPUT AS #2
OPEN "C:\THESIS\COR\" + INFILE$ + "3.XCM" FOR OUTPUT AS #3
OPEN "C:\THESIS\COR\" + INFILE$ + "4.XCM" FOR OUTPUT AS #4
OPEN "C:\THESIS\COR\" + INFILE$ + "5.XCM" FOR OUTPUT AS #5
REM VARIABLE LIST
REM  M            - SLOPE OF LINE
REM  B            - CONSTANT
REM  COUNTS       - NUMBER ABOVE 0
REM  E ( )        - ENERGY ARRAY
REM INPUT M AND B
INPUT "X Coefficient"; M
INPUT "Constant"; B
REM REPEAT STEP FIVE TIMES
REM CALCULATE ENERGIES
COUNT = 0
FOR X = 0 TO 400
Y = M * X + B
IF Y > 0 THEN
COUNT = COUNT + 1
E(X) = Y / 1000
END IF
NEXT X
REM STORE ENERGIES
WRITE #1, COUNT
```

```
FOR X = 0 TO 400
IF E(X) > 0 THEN
PRINT #1, E(X); " "
END IF
NEXT X
REM SECOND
REM CALCULATE ENERGIES
COUNT = 0
FOR X = 401 TO 800
Y = M * X + B
COUNT = COUNT + 1
E(X) = Y / 1000
NEXT X
REM STORE ENERGIES
WRITE #2, COUNT
FOR X = 401 TO 800
PRINT #2, E(X); " "
NEXT X
REM THIRD
REM CALCULATE ENERGIES
COUNT = 0
FOR X = 801 TO 1200
Y = M * X + B
COUNT = COUNT + 1
E(X) = Y / 1000
NEXT X
REM STORE ENERGIES
WRITE #3, COUNT
FOR X = 801 TO 1200
PRINT #3, E(X); " "
NEXT X
REM FOURTH
REM CALCULATE ENERGIES
COUNT = 0
FOR X = 1201 TO 1600
Y = M * X + B
COUNT = COUNT + 1
E(X) = Y / 1000
NEXT X
REM STORE ENERGIES
WRITE #4, COUNT
FOR X = 1201 TO 1600
PRINT #4, E(X); " "
NEXT X
REM FIFTH
REM CALCULATE ENERGIES
COUNT = 0
FOR X = 1601 TO 2047
Y = M * X + B
COUNT = COUNT + 1
E(X) = Y / 1000
NEXT X
REM STORE ENERGIES
WRITE #5, COUNT
FOR X = 1601 TO 2047
PRINT #5, E(X); " "
NEXT X
REM CLOSE FILES
CLOSE
END
```

The next step is to run MAKECMD.BAS which generates the proper command files which will provide inputs to XCOM.

MAKECMD.BAS

```
DECLARE SUB CMNSTF ()
REM THIS QBASIC PROGRAM WRITES THE CMD FILES FOR EXCOM.BAT
REM BY LT JOE THIEN
CLS
REM OPEN FILES
OPEN "C:\THESIS\CMD1" FOR OUTPUT AS #1
OPEN "C:\THESIS\CMD2" FOR OUTPUT AS #2
OPEN "C:\THESIS\CMD3" FOR OUTPUT AS #3
OPEN "C:\THESIS\CMD4" FOR OUTPUT AS #4
OPEN "C:\THESIS\CMD5" FOR OUTPUT AS #5
OPEN "C:\THESIS\CMD6" FOR OUTPUT AS #6
REM INPUT ENERGY LIST
INPUT "Energy File Prefix?"; IN$
REM INPUT SUBSTANCE
START: INPUT "Substance? (A - Air, B - Be, K - Kapton, S - Si)"; SUB$
IF SUB$ = "A" THEN
FOR X = 1 TO 5
PRINT #X, "Air"
PRINT #X, "4"
PRINT #X, "4"
PRINT #X, "N2"
PRINT #X, ".7575"
PRINT #X, "O2"
PRINT #X, ".23"
PRINT #X, "Ar"
PRINT #X, ".012"
PRINT #X, "CO2"
PRINT #X, ".0005"
PRINT #X, "1"
CALL CMNSTF
NEXT X
ELSEIF SUB$ = "B" THEN
FOR X = 1 TO 5
PRINT #X, "Be"
PRINT #X, "2"
PRINT #X, "Be"
PRINT #X, "3"
CALL CMNSTF
NEXT X
ELSEIF SUB$ = "K" THEN
FOR X = 1 TO 5
PRINT #X, "Kapton"
PRINT #X, "3"
PRINT #X, "C22O5N2H10"
CALL CMNSTF
NEXT X
ELSEIF SUB$ = "S" THEN
FOR X = 1 TO 5
PRINT #X, "Si"
PRINT #X, "2"
PRINT #X, "Si"
PRINT #X, "3"
CALL CMNSTF
NEXT X
ELSE
```

```
PRINT "TRY AGAIN"
GOTO START
END IF
REM MAKE COMBINE FILE
PRINT #6, IN$ + SUB$
CLOSE
END

SUB CMNSTF
SHARED X, IN$, SUB$
IF X = 1 THEN X$ = "1"
IF X = 2 THEN X$ = "2"
IF X = 3 THEN X$ = "3"
IF X = 4 THEN X$ = "4"
IF X = 5 THEN X$ = "5"
PRINT #X, "3"
PRINT #X, "2"
PRINT #X, "C:\THESIS\COR\" + IN$ + X$ + ".XCM"
PRINT #X, "3"
PRINT #X, "C:\THESIS\COR\" + IN$ + SUB$ + X$ + ".XCM"
PRINT #X, "1"
END SUB
```

Typical generated command files follow:

CMD1

```
Air
4
4
N2
.7575
O2
.23
Ar
.012
CO2
.0005
1
3
2
C:\THESIS\COR\S930E1.XCM
3
C:\THESIS\COR\S930EA1.XCM
1
```

CMD2

```
Air
4
4
N2
.7575
O2
.23
Ar
.012
CO2
.0005
1
```

3
2
C:\THESIS\COR\S930E2.XCM
3
C:\THESIS\COR\S930EA2.XCM
1

CMD3

Air
4
4
N2
.7575
O2
.23
Ar
.012
CO2
.0005
1
3
2
C:\THESIS\COR\S930E3.XCM
3
C:\THESIS\COR\S930EA3.XCM
1

CMD4

Air
4
4
N2
.7575
O2
.23
Ar
.012
CO2
.0005
1
3
2
C:\THESIS\COR\S930E4.XCM
3
C:\THESIS\COR\S930EA4.XCM
1

CMD5

Air
4
4
N2
.7575
O2
.23
Ar
.012

```
CO2
.0005
1
3
2
C:\THESIS\COR\S930E5.XCM
3
C:\THESIS\COR\S930EA5.XCM
1
```

CMD6

```
S930EA
```

These command files generate 5 separate files of attenuation coefficients that are then combined into one file by the QBasic program COMBINE.BAS with the file name given by the CMD6 file.

COMBINE.BAS

```
REM QBASIC FILE TO COMBINE XCOM FILES INTO ONE FILE FOR Q PRO
REM BY LT JOE THIEN
CLS
INPUT "File name to work on (name only)"; INFILE$
REM OPEN FILES
OPEN "C:\THESIS\COR\" + INFILE$ + "1.XCM" FOR INPUT AS #1
OPEN "C:\THESIS\COR\" + INFILE$ + "2.XCM" FOR INPUT AS #2
OPEN "C:\THESIS\COR\" + INFILE$ + "3.XCM" FOR INPUT AS #3
OPEN "C:\THESIS\COR\" + INFILE$ + "4.XCM" FOR INPUT AS #4
OPEN "C:\THESIS\COR\" + INFILE$ + "5.XCM" FOR INPUT AS #5
OPEN "C:\THESIS\COR\" + INFILE$ + ".XCM" FOR OUTPUT AS #6
REM DO FIRST FILE
REM DO FIRST PAGE
FOR X = 1 TO 13
LINE INPUT #1, A$
NEXT X
FOR X = 1 TO 44
INPUT #1, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
NEXT X
REM DO REST OF PAGES
DO
FOR X = 1 TO 14
LINE INPUT #1, A$
IF EOF(1) = -1 THEN EXIT DO
NEXT X
FOR X = 1 TO 44
INPUT #1, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
IF EOF(1) = -1 THEN EXIT DO
NEXT X
LOOP
REM DO SECOND FILE
REM DO FIRST PAGE
```

```
FOR X = 1 TO 13
LINE INPUT #2, A$
NEXT X
FOR X = 1 TO 44
INPUT #2, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
NEXT X
REM DO REST OF PAGES
DO
FOR X = 1 TO 14
LINE INPUT #2, A$
IF EOF(2) = -1 THEN EXIT DO
NEXT X
FOR X = 1 TO 44
INPUT #2, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
IF EOF(2) = -1 THEN EXIT DO
NEXT X
LOOP
REM DO THIRD FILE
REM DO FIRST PAGE
FOR X = 1 TO 13
LINE INPUT #3, A$
NEXT X
FOR X = 1 TO 44
INPUT #3, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
NEXT X
REM DO REST OF PAGES
DO
FOR X = 1 TO 14
LINE INPUT #3, A$
IF EOF(3) = -1 THEN EXIT DO
NEXT X
FOR X = 1 TO 44
INPUT #3, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
IF EOF(3) = -1 THEN EXIT DO
NEXT X
LOOP
REM DO FOURTH FILE
REM DO FIRST PAGE
FOR X = 1 TO 13
LINE INPUT #4, A$
NEXT X
FOR X = 1 TO 44
INPUT #4, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
NEXT X
REM DO REST OF PAGES
DO
FOR X = 1 TO 14
LINE INPUT #4, A$
IF EOF(4) = -1 THEN EXIT DO
NEXT X
FOR X = 1 TO 44
INPUT #4, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
IF EOF(4) = -1 THEN EXIT DO
NEXT X
LOOP
REM DO FIFTH FILE
```

```
REM DO FIRST PAGE
FOR X = 1 TO 13
LINE INPUT #5, A$
NEXT X
FOR X = 1 TO 44
INPUT #5, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
NEXT X
REM DO REST OF PAGES
DO
FOR X = 1 TO 14
LINE INPUT #5, A$
IF EOF(5) = -1 THEN EXIT DO
NEXT X
FOR X = 1 TO 44
INPUT #5, A1, A2, A3, A4, A5, A6, A7, A8
WRITE #6, A1, A7
IF EOF(5) = -1 THEN EXIT DO
NEXT X
LOOP
REM CLOSE FILES
CLOSE
END
```

The batch file that runs XCOM using the command files and then combines the files into one file of attenuation coefficients is EXCOM.BAT.

EXCOM.BAT

```
cd xcomm
xcom < c:\thesis\cmd1
xcom < c:\thesis\cmd2
xcom < c:\thesis\cmd3
xcom < c:\thesis\cmd4
xcom < c:\thesis\cmd5
qbasic /run c:\thesis\baspro\combine < c:\thesis\cmd6
```

The file of attenuation coefficients generated is then imported into the spreadsheet file containing the PXR spectrum data where the corrected counts are then calculated.

APPENDIX E. CORRECTED PXR DATA

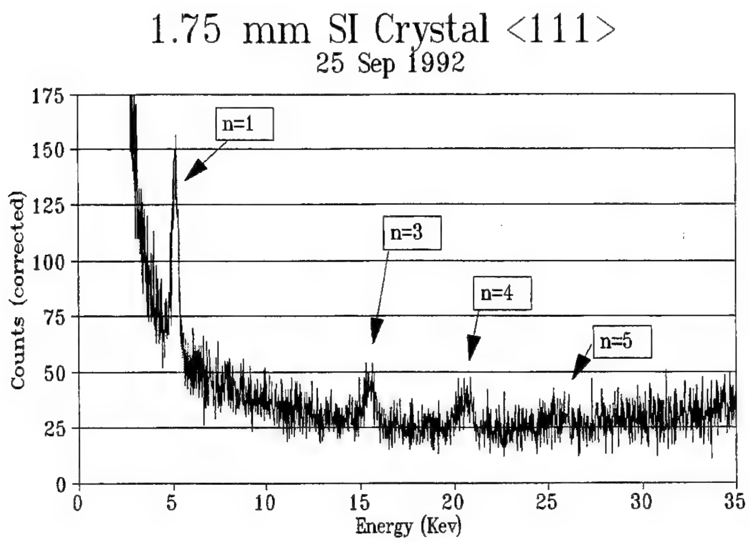
This appendix contains the corrected PXR spectrums and the Peakfit graphical and numerical analysis of the spectrums.

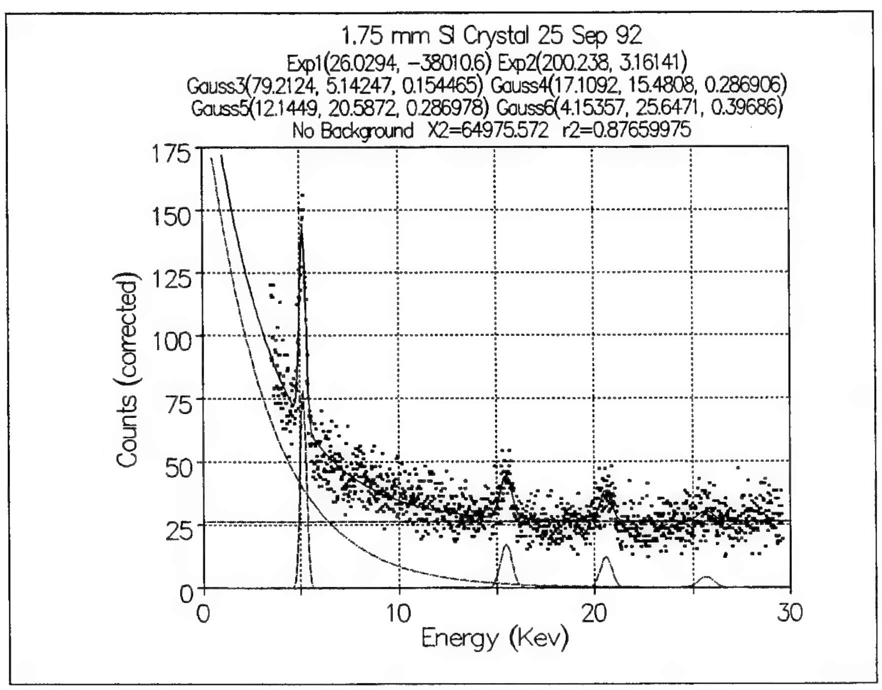
Section	Date	Beam Energy	Target
E1	25 Sep 92	96 MeV	1.75mm Si
E2	29-30 Sep 92	96 MeV	1.75mm Si
E3	02 Dec 92	91 MeV	1.75mm Si
E4	01 Dec 92	92 MeV	1mm LiF
E5	03 Dec 92	62 MeV	1mm LiF
E6	22 Oct 92	95 MeV	1mm LiF
E7	05 Sep 91	85 MeV	320μm Si
E8	05 Sep 91	85 MeV	44μm Si
E9	23 Jul 91	85 MeV	20μm Si

Table 13. Corrected PXR Data.

Sections E7, E8 and E9 are reanalysis of PXR spectrums reported on in Reference 5.

E1. CORRECTED SILICON DATA TAKEN 25 SEPTEMBER 1992





PeakFit Numerical Summary

Description: 1.75 mm SI Crystal 25 Sep 92
X-Y Table Size: 1970 Active Points: 1383
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: S925X04.PRN

Curve-Fit Std Error= 6.89430984 r2= 0.876599746

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	26.029414	-3.8e+04		
2	Exp	200.23753	3.161406		
3	Gaussian	79.212415	5.1424715	0.1544654	
4	Gaussian	17.109202	15.480849	0.2869062	
5	Gaussian	12.144866	20.587158	0.2869778	
6	Gaussian	4.1535694	25.64711	0.3968604	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Exp	0	0	0	0	0
3	Gaussian	79.212415	5.1424715	0.3637379	30.670054	54.922234
4	Gaussian	17.109202	15.480849	0.6756114	12.304374	22.033992
5	Gaussian	12.144866	20.587158	0.6757783	8.7363695	15.644607
6	Gaussian	4.1535694	25.64711	0.9345325	4.1318939	7.3991668
	Total				55.842691	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	26.02941372	1.593080057	16.33904938	22.91016809	29.14865936
Rte1	-38010.5736	3.7999e+06	-0.01000306	-7.4782e+06	7.40217e+06

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	200.237529	10.47096613	19.12311877	179.7354109	220.7396471
Rte1	3.161405963	0.155264428	20.36143112	2.857398711	3.465413215

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
79.21241479	5.14247151	0.363737903	30.67005359
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.960602694	5.324340597	0.181868816	0.181869087

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	79.21241479	2.248162225	35.23429667	74.81052037	83.6143092
Ctr	5.14247151	0.005000662	1028.358149	5.13268023	5.15226279
Wid1	0.154465425	0.00519876	29.71197218	0.144286268	0.164644581

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
17.10920164	15.48084927	0.675611409	12.30437411
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.14304343	15.81865484	0.337805844	0.337805564

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	17.10920164	1.645359572	10.39845753	13.88759288	20.3308104
Ctr	15.48084927	0.031498122	491.4848273	15.41917605	15.5425225
Wid1	0.286906155	0.03255662	8.812528777	0.223160396	0.350651913

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
12.14486586	20.58715792	0.675778313	8.736369496
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
20.24926921	20.92504752	0.33788871	0.337889603

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	12.14486586	1.639557808	7.407403267	8.93461694	15.35511478
Ctr	20.58715792	0.044384676	463.8348156	20.50025287	20.67406297
Wid1	0.28697777	0.04544403	6.314971885	0.197998506	0.375957034

Peak# 6 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
4.153569401	25.64711001	0.934532456	4.131893877
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
25.17984292	26.11437538	0.467267082	0.467265374

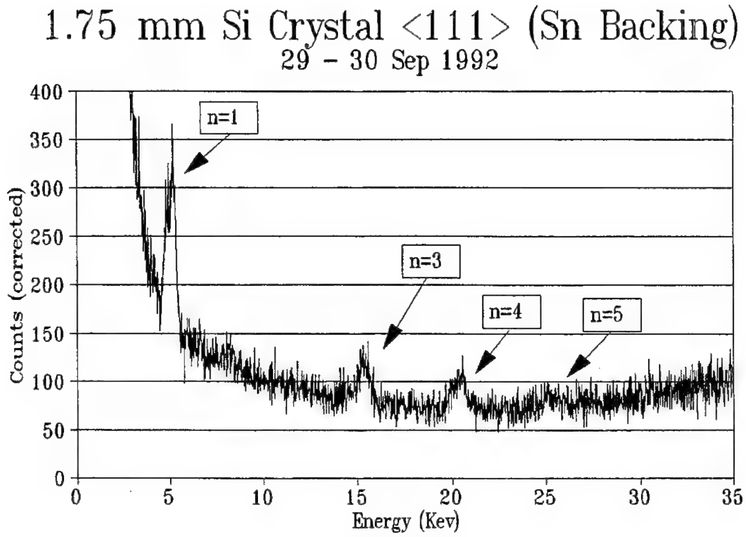
Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	4.153569401	1.406971917	2.952133835	1.398722906	6.908415896
Ctr	25.64711001	0.152730479	167.9239808	25.34806422	25.94615579
Wid1	0.396860384	0.160407639	2.474074093	0.082782742	0.710938025

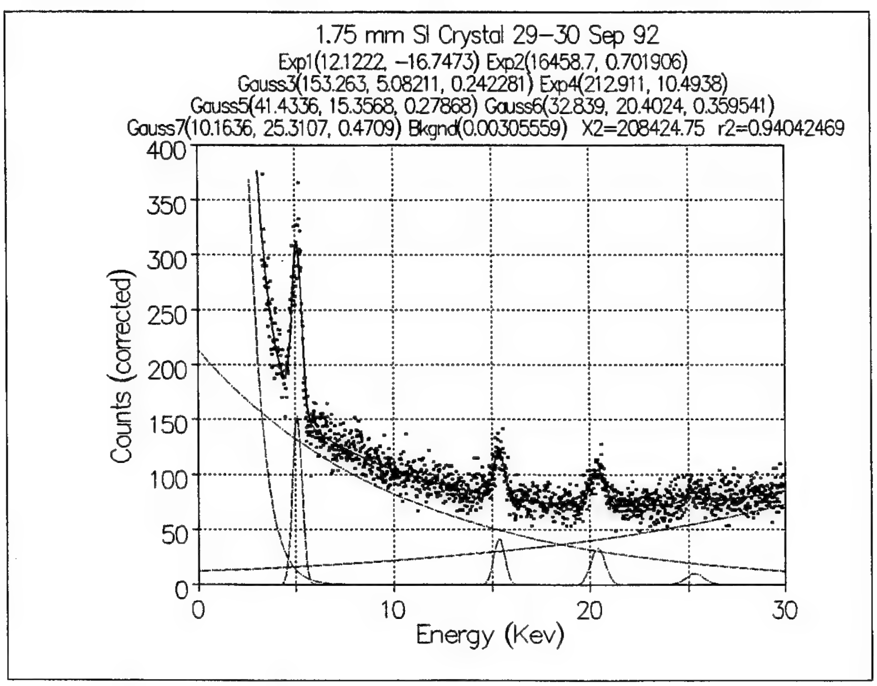
Total Peaks= 6 Coefficient Count= 16 Fitted Count=16

Std Error for Curve= 6.894309843 r2= 0.8765997465

Source	Sum of Squares	DF	Mean Square	F
Regr	461567.69	15	30771.179	647.385
Error	64975.572	1367	47.531508	
Total	526543.26	1382		

E2. CORRECTED SILICON DATA TAKEN 29-30 SEPTEMBER 1992





PeakFit Numerical Summary

Description: 1.75 mm SI Crystal 29-30 Sep 92
X-Y Table Size: 1965 Active Points: 1481
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: S930X13.PRN

Curve-Fit Std Error= 11.9399074 r2= 0.940424692

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	0.0030556			

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	12.122162	-16.74733		
2	Exp	1.646e+04	0.7019065		
3	Gaussian	153.2625	5.0821085	0.2422811	
4	Exp	212.91071	10.493779		
5	Gaussian	41.433593	15.356805	0.2786795	
6	Gaussian	32.838982	20.402398	0.3595408	
7	Gaussian	10.163553	25.310678	0.4708995	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Exp	0	0	0	0	0
3	Gaussian	153.2625	5.0821085	0.5705279	93.077668	56.888801
4	Exp	0	0	0	0	0
5	Gaussian	41.433593	15.356805	0.6562393	28.943256	17.690034
6	Gaussian	32.838982	20.402398	0.8466525	29.595644	18.088772
7	Gaussian	10.163553	25.310678	1.108881	11.996774	7.3323936
	Total				163.61334	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	12.12216203	74.26979639	0.163217925	-133.26298	157.507304
Rte1	-16.747331	35.26316404	-0.47492423	-85.7759316	52.28126964

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	16458.66777	6249.162674	2.633739692	4225.762246	28691.5733
Rte1	0.701906466	0.059569993	11.78288652	0.585296589	0.818516344

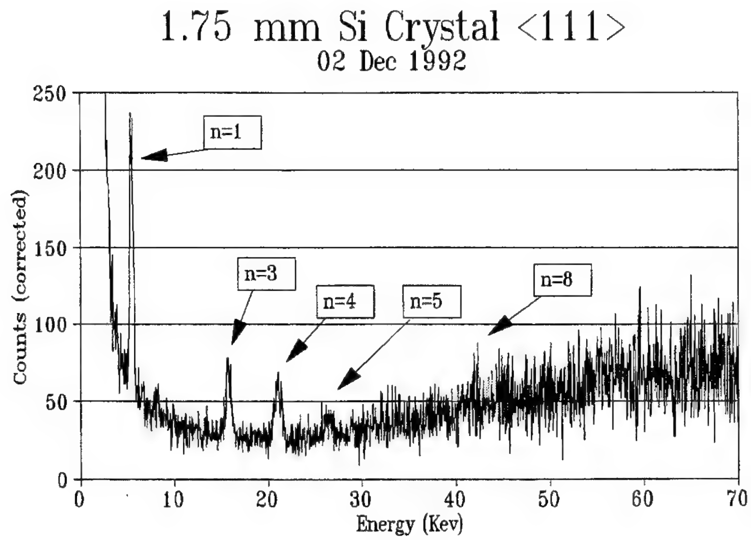
Peak# 3 Gaussian

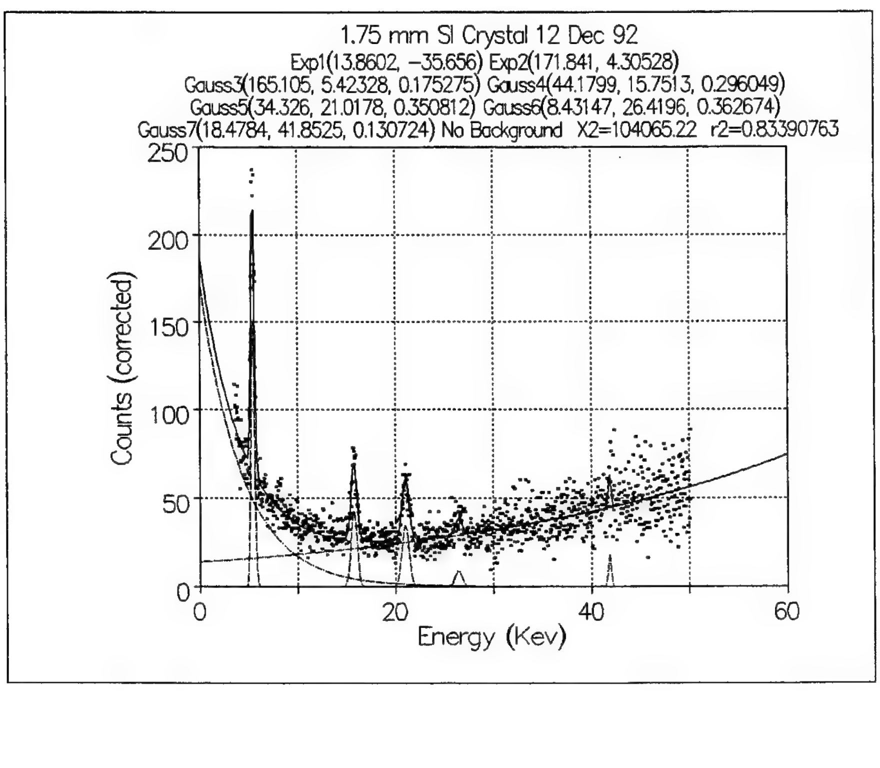
PkAmpl	PkCtr	Wid@HM	Area
153.2625006	5.082108483	0.57052792	93.07766787
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.796844698	5.367372618	0.285263785	0.285264135

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	153.2625006	3.189301189	48.05519816	147.019357	159.5056442
Ctr	5.082108483	0.005618231	904.5744836	5.071110643	5.093106323
Wid1	0.242281095	0.006299214	38.46211565	0.229950213	0.254611977

```
Peak# 4  Exp
  PkAmpl        PkCtr         Wid@HM        Area
  0             0             0             0
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  0             0             0             0
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  212.9107053   106.8632468   1.992366053   3.72299949    422.0984111
 Rtel  10.49377862   7.541573357   1.391457475   -4.2690559    25.25661314

Peak# 5  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  41.43359267   15.35680535   0.65623935    28.94325591
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  15.02868592   15.68492527   0.328119425   0.328119924
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  41.43359267   2.83287281    14.62599822   35.88816726   46.97901808
  Ctr  15.35680535   0.021676455   708.4555853   15.3143731    15.3992376
 Wid1  0.278679513   0.022635836   12.31143024   0.23436925    0.322989776

Peak# 6  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  32.83898217   20.40239839   0.846652511   29.59564392
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  19.97907214   20.82572465   0.42332625    0.423326261
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  32.83898217   2.506833033   13.09978835   27.93178848   37.74617587
  Ctr  20.40239839   0.031122897   655.5430414   20.34147447   20.4633223
 Wid1  0.359540816   0.0328834     10.93380898   0.295170667   0.423910964

Peak# 7  Gaussian
  PkAmpl        PkCtr         Wid@HM        Area
  10.16355297   25.31067835   1.108881012   11.9967742
  XL @HM        XR @HM        Ctr-XL@HM     Ctr-XR@HM
  24.75623736   25.86511837   0.554440998   0.554440014
 Parm  Value         Std Error     t-value       95% Confidence Limits
 Ampl  10.16355297   2.258453449   4.500226903   5.742569054   14.58453689
  Ctr  25.31067835   0.115258579   219.5990846   25.08505656   25.53630015
 Wid1  0.470899542   0.129421478   3.638496104   0.217553487   0.724245597

Background  Order=0    Area=0.08123364874
 Parm     Value        Std Error     t-value       95% Confidence Limits
  a     0.003055592   203.5509924   1.50114e-05   -398.453536   398.4596474

Total Peaks= 7   Coefficient Count= 19   Fitted Count=19
Std Error for Curve= 11.93990743      r2= 0.9404246919
Source    Sum of Squares     DF       Mean Square        F
Regr      3290084.2          18       182782.46          1282.13
Error     208424.75          1462     142.56139
Total     3498509            1480
```

E3. CORRECTED SILICON DATA TAKEN 02 DECEMBER 1992





PeakFit Numerical Summary

Description: 1.75 mm SI Crystal 02 Dec 92
X-Y Table Size: 1997 Active Points: 1258
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: S1202Y2.PRN

Curve-Fit Std Error= 9.16467663 r2= 0.83390763

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	13.860178	-35.65605		
2	Exp	171.84102	4.3052752		
3	Gaussian	165.10457	5.4232754	0.1752754	
4	Gaussian	44.179879	15.751283	0.2960488	
5	Gaussian	34.325985	21.01775	0.350812	
6	Gaussian	8.4314709	26.419642	0.3626737	
7	Gaussian	18.47842	41.852522	0.1307236	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Exp	0	0	0	0	0
3	Gaussian	165.10457	5.4232754	0.4127413	72.538731	48.609154
4	Gaussian	44.179879	15.751283	0.6971407	32.785201	21.969792
5	Gaussian	34.325985	21.01775	0.8260983	30.184741	20.22719
6	Gaussian	8.4314709	26.419642	0.8540295	7.6649499	5.1363833
7	Gaussian	18.47842	41.852522	0.3078256	6.0549176	4.0574796
	Total				149.22854	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	13.86017849	0.623624855	22.22518616	12.63871239	15.0816446
Rte1	-35.6560479	1.405974361	-25.3603827	-38.409867	-32.9022288

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	171.84102	8.750813846	19.63714724	154.7011924	188.9808476
Rte1	4.305275236	0.185919031	23.15672163	3.941123947	4.669426524

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
165.1045743	5.423275385	0.412741277	72.53873103
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
5.216904719	5.629645995	0.206370666	0.20637061

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	165.1045743	3.925379469	42.06079326	157.4161091	172.7930395
Ctr	5.423275385	0.004760157	1139.306087	5.413951879	5.432598891
Wid1	0.175275378	0.00492839	35.56442591	0.16562236	0.184928396

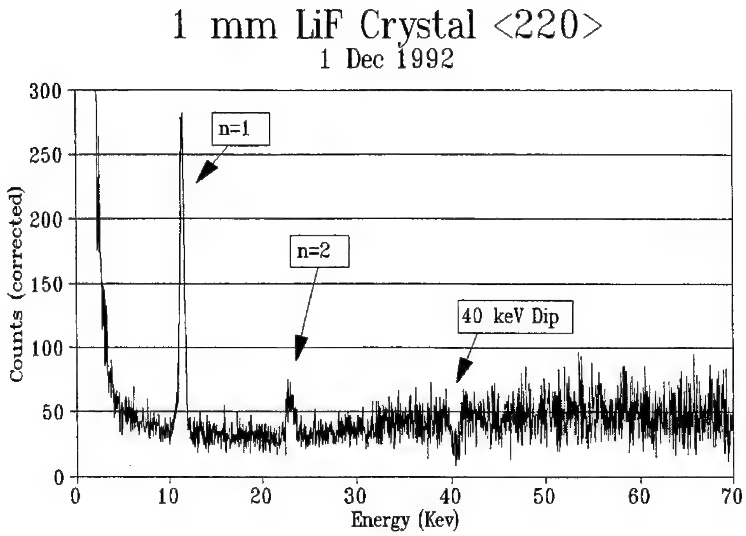
Peak# 4 Gaussian

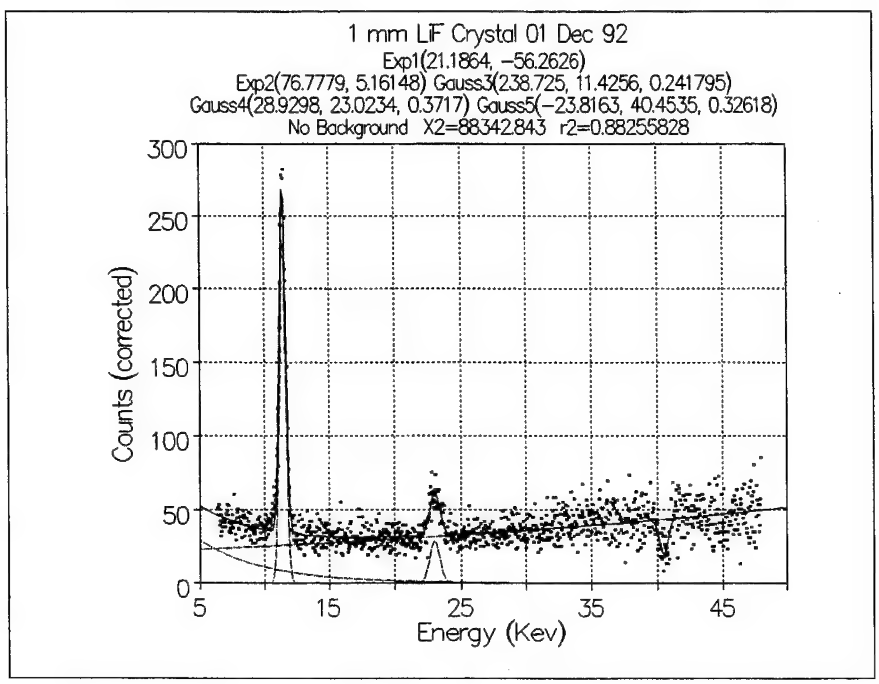
PkAmpl	PkCtr	Wid@HM	Area
44.17987944	15.75128332	0.697140669	32.78520059
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.40271297	16.09985363	0.348570356	0.348570313

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	44.17987944	2.998991249	14.73157998	38.30588943	50.05386944
Ctr	15.75128332	0.023092129	682.1061662	15.7060538	15.79651284
Wid1	0.296048845	0.023435373	12.63256396	0.250147029	0.341950662

```
Peak# 5  Gaussian
  PkAmpl         PkCtr          Wid@HM         Area
  34.32598528    21.01775002    0.826098335    30.184741
  XL @HM         XR @HM         Ctr-XL@HM      Ctr-XR@HM
  20.60470056    21.43079889    0.413049459    0.413048876
 Parm  Value          Std Error      t-value        95% Confidence Limits
 Ampl  34.32598528    2.758950904    12.44168036    28.92215156    39.729819
  Ctr  21.01775002    0.032350435    649.689875     20.95438667    21.08111337
 Widl  0.350812044    0.032969116    10.64062622    0.286236911    0.415387178

Peak# 6  Gaussian
  PkAmpl         PkCtr          Wid@HM         Area
  8.43147095     26.41964186    0.85402949     7.664949866
  XL @HM         XR @HM         Ctr-XL@HM      Ctr-XR@HM
  25.99262708    26.84665657    0.427014773    0.427014716
 Parm  Value          Std Error      t-value        95% Confidence Limits
 Ampl  8.43147095     2.714731394    3.105821434    3.114248007    13.74869389
  Ctr  26.41964186    0.133907848    197.2971879    26.15736254    26.68192117
 Widl  0.362673685    0.136663222    2.653776779    0.094997545    0.630349824

Peak# 7  Gaussian
  PkAmpl         PkCtr          Wid@HM         Area
  18.4784201     41.85252216    0.30782563     6.054917589
  XL @HM         XR @HM         Ctr-XL@HM      Ctr-XR@HM
  41.69860922    42.00643485    0.153912939    0.153912691
 Parm  Value          Std Error      t-value        95% Confidence Limits
 Ampl  18.4784201     4.49921355     4.10703335     9.666011782    27.29082842
  Ctr  41.85252216    0.036682513    1140.939345    41.78067376    41.92437055
 Widl  0.130723607    0.03689476     3.543148343    0.058459492    0.202987723

Total Peaks= 7    Coefficient Count= 19    Fitted Count=19
Std Error for Curve= 9.164676633      r2= 0.8339076305
Source     Sum of Squares      DF         Mean Square          F
Regr       522485.05           18         29026.947            345.595
Error      104065.22           1239       83.991298
Total      626550.26           1257
```

E4. CORRECTED LITHIUM FLUORIDE DATA TAKEN 01 DECEMBER 1992





PeakFit Numerical Summary

Description: 1 mm LiF Crystal 01 Dec 92
X-Y Table Size: 2004 Active Points: 1130
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: L1201Y1.PRN

Curve-Fit Std Error= 8.89322131 r2= 0.882558281

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	21.18641	-56.26264		
2	Exp	76.777884	5.1614755		
3	Gaussian	238.72507	11.425575	0.2417947	
4	Gaussian	28.929756	23.023429	0.3717003	
5	Gaussian	-23.8163	40.453499	0.3261802	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Exp	0	0	0	0	0
3	Gaussian	238.72507	11.425575	0.5693818	144.68876	95.083278
4	Gaussian	28.929756	23.023429	0.8752858	26.954306	17.71322
5	Gaussian	-23.8163	40.453499	0.7681003	-19.4725	-12.7965
	Total				152.17056	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	21.18641035	1.207505209	17.54560576	18.82052274	23.55229796
Rte1	-56.2626355	4.582864483	-12.27674	-65.2419279	-47.2833431

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	76.77788448	18.02824112	4.258756247	41.45481343	112.1009555
Rte1	5.161475525	0.904410951	5.707002463	3.389446181	6.933504869

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
238.7250704	11.42557523	0.569381806	144.6887598
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
11.14088438	11.71026619	0.284690847	0.284690959

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	238.7250704	3.23062574	73.89437513	232.3952447	245.054896
Ctr	11.42557523	0.003735816	3058.387725	11.41825557	11.43289488
Wid1	0.241794718	0.003860361	62.63526858	0.234231041	0.249358395

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
28.92975592	23.02342917	0.875285763	26.95430645
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
22.58578704	23.4610728	0.43764213	0.437643633

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	28.92975592	2.594275791	11.15138029	23.84674269	34.01276915
Ctr	23.02342917	0.038218482	602.4161141	22.94854698	23.09831136
Wid1	0.371700295	0.03902377	9.524971407	0.29524029	0.448160301

Peak# 5 Gaussian

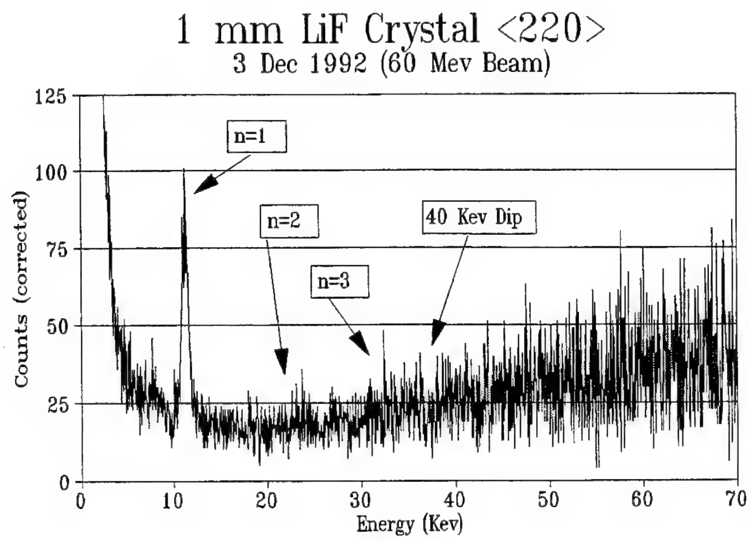
PkAmpl	PkCtr	Wid@HM	Area
-23.8162952	40.45349852	0.768100277	-19.472503
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
40.06944741	40.83754768	0.384051114	0.384049164

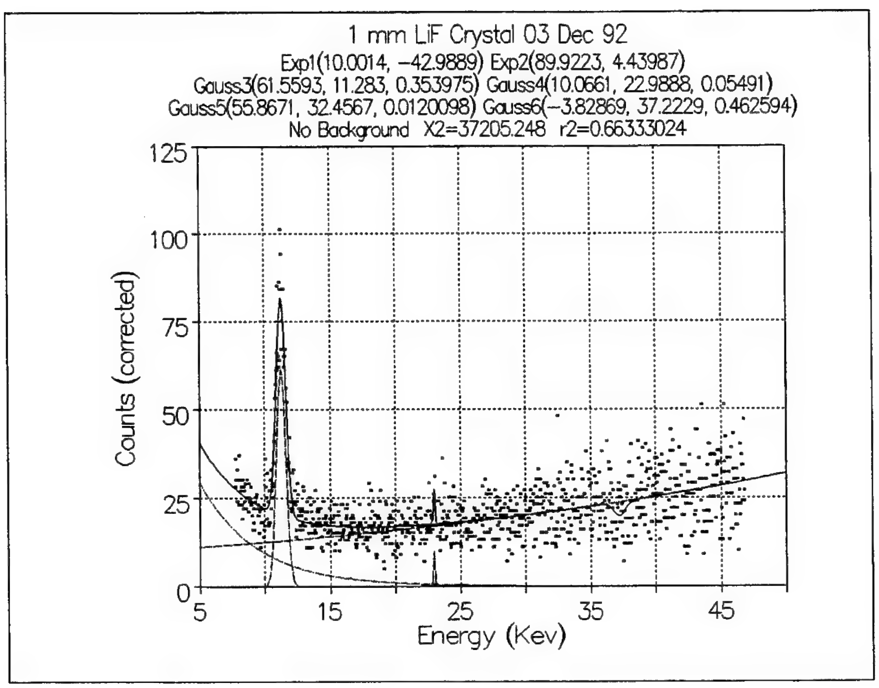
Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	-23.8162952	2.765652225	-8.61145698	-29.2350895	-18.3975009
Ctr	40.45349852	0.043489747	930.1847352	40.36828824	40.5387088
Wid1	0.326180241	0.04424243	7.372566112	0.239495218	0.412865264

Total Peaks= 5 Coefficient Count= 13 Fitted Count=13
Std Error for Curve= 8.893221315 r2= 0.8825582811

Source	Sum of Squares	DF	Mean Square	F
Regr	663884.25	12	55323.688	699.508
Error	88342.843	1117	79.089385	
Total	752227.1	1129		

E5. CORRECTED LITHIUM FLUORIDE DATA TAKEN 03 DECEMBER 1992





PeakFit Numerical Summary

Description: 1 mm LiF Crystal 03 Dec 92
X-Y Table Size: 1952 Active Points: 1033
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: L1203Y1.PRN

Curve-Fit Std Error= 6.04841558 r2= 0.663330244

Curve-Fit Coefficients

Peak#	Type	Ampl	Rtel	Amp2	Rte2
1	Exp	10.001403	-42.98892		
2	Exp	89.922291	4.4398657		
3	Gaussian	61.559312	11.283016	0.3539753	
4	Gaussian	10.066107	22.988784	0.05491	
5	Gaussian	55.867064	32.456654	0.0120098	
6	Gaussian	-3.828691	37.222922	0.4625939	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Exp	0	0	0	0	0
3	Gaussian	61.559312	11.283016	0.8335473	54.620635	102.57707
4	Gaussian	10.066107	22.988784	0.1293006	1.3854892	2.6019366
5	Gaussian	55.867064	32.456654	0.0282783	1.6818235	3.1584497
6	Gaussian	-3.828691	37.222922	1.0893306	-4.439562	-8.337459
	Total				53.248385	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	10.00140347	0.676803096	14.77741979	8.674938642	11.32786829
Rtel	-42.9889177	3.237753966	-13.2773886	-49.3345842	-36.6432511

Peak# 2 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	89.92229099	28.95302318	3.10579971	33.17732777	146.6672542
Rtel	4.439865717	0.759119147	5.848707326	2.952069855	5.92766158

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
61.55931198	11.28301626	0.833547338	54.62063491
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
10.86624249	11.69978983	0.416773765	0.416773573

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	61.55931198	1.858652281	33.12040268	57.91654367	65.20208029
Ctr	11.28301626	0.0121013	932.3804849	11.25929895	11.30673357
Wid1	0.353975327	0.012803321	27.64714924	0.328882128	0.379068526

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
10.06610724	22.98878373	0.129300575	1.385489219
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
22.92413413	23.05343471	0.064649591	0.064650983

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	10.06610724	4.621567163	2.178072262	1.008308441	19.12390604
Ctr	22.98878373	0.029080543	790.5211241	22.93178884	23.04577862
Wid1	0.054910018	0.029170129	1.88240576	-0.00226045	0.112080486

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
55.86706436	32.45665385	0.02827827	1.681823491
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
32.44251459	32.47079286	0.014139256	0.014139014

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	55.86706436	9797.443081	0.005702209	-19146.119	19257.85312
Ctr	32.45665385	0.641442609	50.59946657	31.19949196	33.71381573
Widl	0.012009768	0.896566306	0.013395292	-1.74516846	1.769187998

Peak# 6 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
-3.8286907	37.22292215	1.089330592	-4.43956231
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
36.67825711	37.7675877	0.544665043	0.544665549

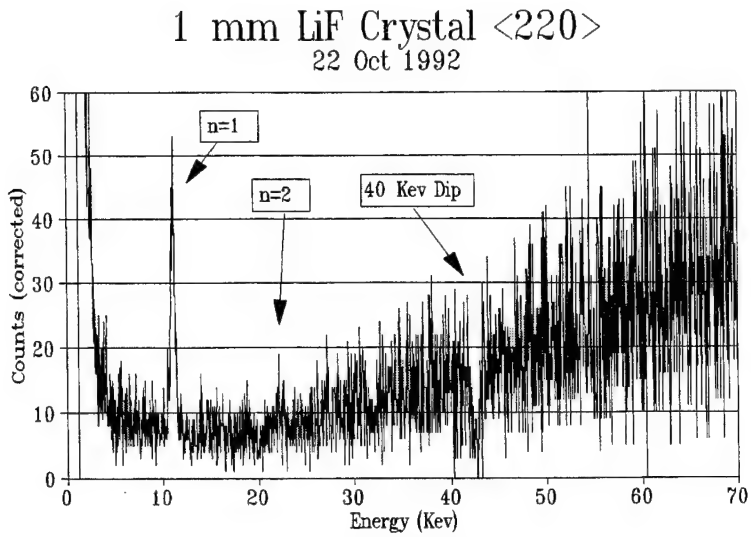
Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	-3.8286907	1.601915424	-2.39007044	-6.96828103	-0.68910036
Ctr	37.22292215	0.221998233	167.6721549	36.78782833	37.65801598
Widl	0.462593901	0.226600052	2.041455401	0.018480982	0.90670682

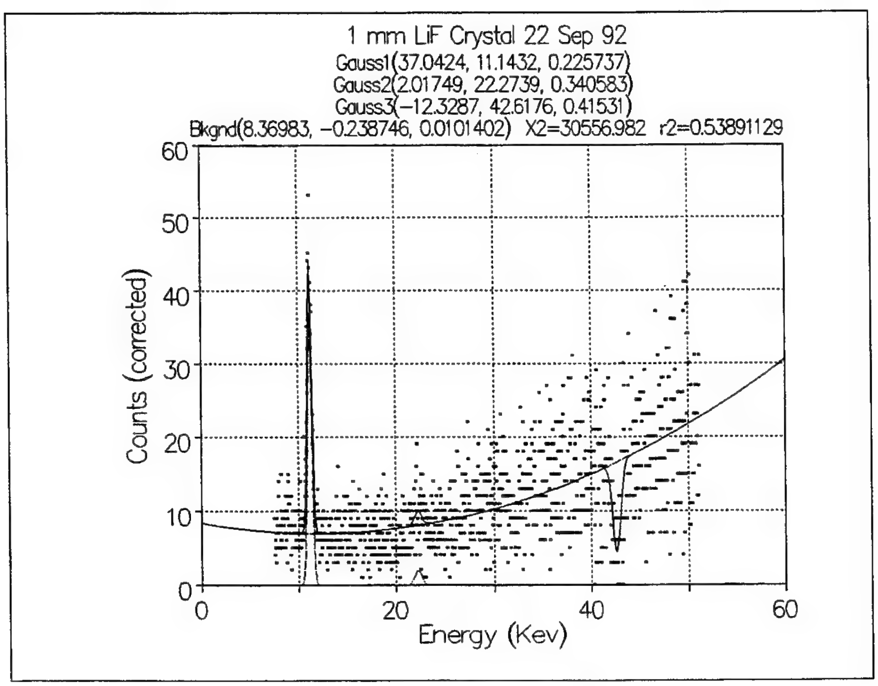
Total Peaks= 6 Coefficient Count= 16 Fitted Count=16

Std Error for Curve= 6.04841558 r2= 0.6633302438

Source	Sum of Squares	DF	Mean Square	F
Regr	73304.375	15	4886.9583	133.584
Error	37205.248	1017	36.583331	
Total	110509.62	1032		

E6. CORRECTED LITHIUM FLUORIDE DATA TAKEN 22 OCTOBER 1992





PeakFit Numerical Summary

Description: 1 mm LiF Crystal 22 Oct 92
X-Y Table Size: 2020   Active Points: 1206
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: L1022X1.PRN

Curve-Fit Std Error= 5.05886473   r2= 0.538911288

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 2	8.3698256	-0.238746	0.0101402	

Curve-Fit Coefficients

Peak#	Type	Ampl	Ctr	Wid1	Wid2	Wid3
1	Gaussian	37.042364	11.143188	0.2257372		
2	Gaussian	2.0174933	22.273939	0.3405828		
3	Gaussian	-12.32871	42.617646	0.4153104		

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Gaussian	37.042364	11.143188	0.5315696	20.96002	212.83898
2	Gaussian	2.0174933	22.273939	0.8020092	1.722363	17.489773
3	Gaussian	-12.32871	42.617646	0.977982	-12.83455	-130.3288
	Total				9.8478293	100

Peak# 1 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
37.042364	11.14318764	0.531569629	20.96001986
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
10.87740284	11.40897247	0.265784793	0.265784836

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	37.042364	1.878596176	19.71810891	33.36239072	40.72233728
Ctr	11.14318764	0.013116124	849.5793298	11.11749452	11.16888075
Wid1	0.2257372	0.01342549	16.81407592	0.199438071	0.252036329

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
2.017493298	22.27393941	0.802009231	1.722362997
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
21.87293532	22.67494455	0.40100409	0.401005141

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	2.017493298	1.524711863	1.323196433	-0.96925766	5.004244251
Ctr	22.27393941	0.295798085	75.30116157	21.69450192	22.8533769
Wid1	0.340582756	0.300035509	1.135141493	-0.2471554	0.928320914

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
-12.3287141	42.61764584	0.977981987	-12.8345535
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
42.12865522	43.10663721	0.488990616	0.48899137

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	-12.3287141	1.383324768	-8.91237861	-15.0385025	-9.61892564
Ctr	42.61764584	0.053462657	797.1479156	42.51291809	42.72237359
Wid1	0.415310364	0.054520574	7.617497977	0.308510266	0.522110462

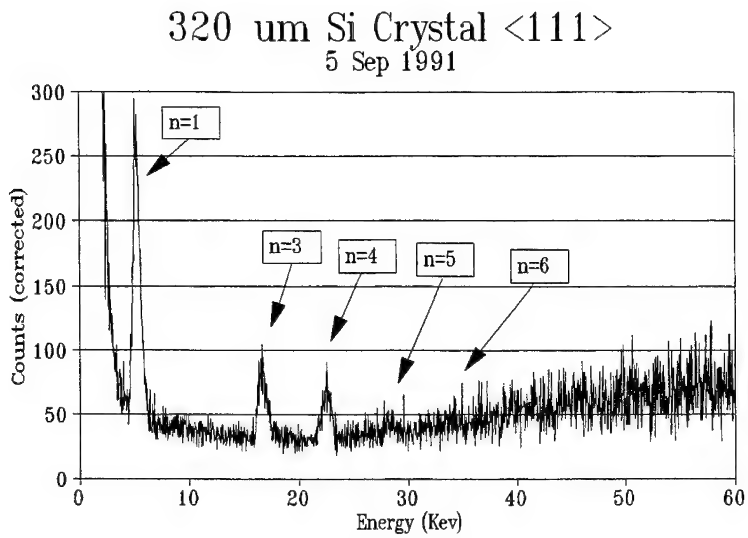
Background Order=2   Area=509.99836294

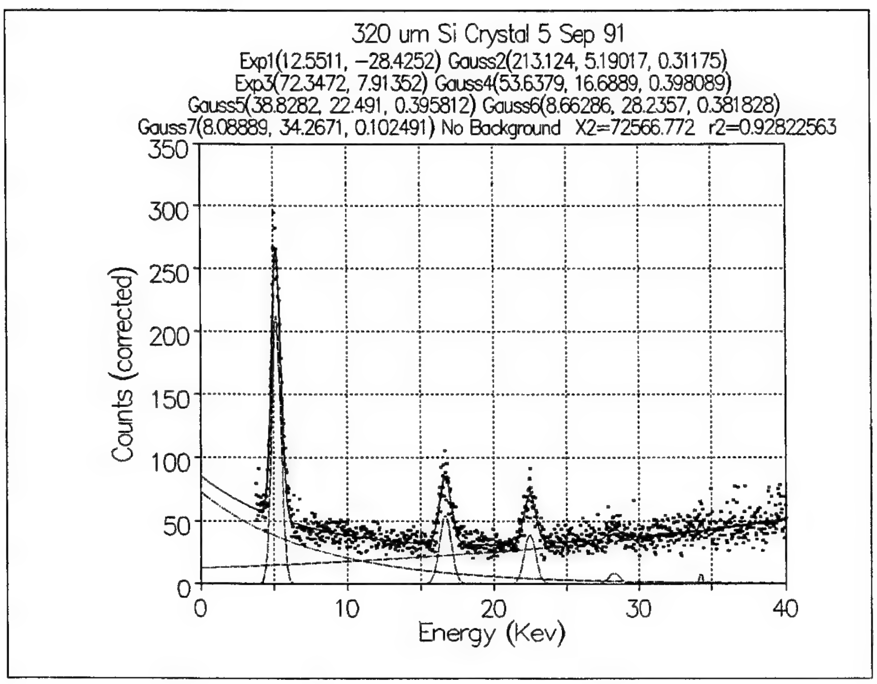
Parm	Value	Std Error	t-value	95% Confidence Limits	
a	8.369825611	0.850715621	9.838570494	6.70336275	10.03628847
b	-0.23874592	0.063704623	-3.74770168	-0.36353661	-0.11395523
c	0.010140167	0.001060948	9.557651491	0.008061882	0.012218452

Total Peaks= 3   Coefficient Count= 12   Fitted Count=12
Std Error for Curve= 5.058864727   r2= 0.5389112875

Source	Sum of Squares	DF	Mean Square	F
Regr	35714.391	11	3246.7628	126.866
Error	30556.982	1194	25.592112	
Total	66271.373	1205		

E7. CORRECTED SILICON DATA TAKEN 05 SEPTEMBER 1991





PeakFit Numerical Summary

Description: 320 um Si Crystal 5 Sep 91
X-Y Table Size: 1916   Active Points: 1085
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: S905T32.PRN

Curve-Fit Std Error= 8.25069059   r2= 0.928225626

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	12.551064	-28.42516		
2	Gaussian	213.12394	5.1901745	0.3117504	
3	Exp	72.347153	7.9135208		
4	Gaussian	53.637888	16.688854	0.398089	
5	Gaussian	38.828177	22.490957	0.3958121	
6	Gaussian	8.6628599	28.235708	0.3818276	
7	Gaussian	8.088892	34.267095	0.1024914	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Gaussian	213.12394	5.1901745	0.7341157	166.54386	61.92146
3	Exp	0	0	0	0	0
4	Gaussian	53.637888	16.688854	0.9374266	53.523152	19.900053
5	Gaussian	38.828177	22.490957	0.9320641	38.523511	14.323146
6	Gaussian	8.6628599	28.235708	0.8991324	8.2912199	3.082698
7	Gaussian	8.088892	34.267095	0.2413483	2.0781006	0.7726434
	Total				268.95985	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	12.5510644	1.519242852	8.261394404	9.573941785	15.52818701
Rte1	-28.4251578	2.626347992	-10.8230737	-33.571774	-23.2785415

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
213.1239437	5.190174534	0.734115726	166.5438641
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.823116693	5.557232419	0.367057841	0.367057886

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	213.1239437	2.596736018	82.07378117	208.0353553	218.212532
Ctr	5.190174534	0.004232279	1226.330947	5.18188092	5.198468147
Wid1	0.311750379	0.00477205	65.32839382	0.302399024	0.321101733

Peak# 3 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	72.34715305	4.344022989	16.65441302	63.83456466	80.85974144
Rte1	7.913520815	0.826097911	9.579398168	6.294691563	9.532350068

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
53.63788803	16.68885362	0.937426613	53.52315151
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
16.22014053	17.15756715	0.468713085	0.468713528

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	53.63788803	2.221073018	24.14953835	49.2854524	57.99032365
Ctr	16.68885362	0.018850869	885.3094927	16.65191328	16.72579396
Wid1	0.398088989	0.019406534	20.51314153	0.360059761	0.436118217

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
38.82817702	22.49095715	0.932064123	38.52351103
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
22.02492424	22.95698837	0.466032906	0.466031217

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	38.82817702	2.230418535	17.40847128	34.45742783	43.1989262
Ctr	22.49095715	0.025959774	866.3772167	22.44008613	22.54182817
Wid1	0.395812091	0.026831001	14.75204359	0.34323381	0.448390373

Peak# 6 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
8.662859917	28.23570809	0.899132382	8.291219864
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
27.78614226	28.68527464	0.44956583	0.449566552

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	8.662859917	2.271326081	3.814009794	4.211947921	13.11377191
Ctr	28.23570809	0.114272564	247.0908764	28.0117785	28.45963768
Wid1	0.381827602	0.118170368	3.231162005	0.150259836	0.613395368

Peak# 7 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
8.088892034	34.26709478	0.241348268	2.078100552
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
34.14642035	34.38776861	0.120674433	0.120673835

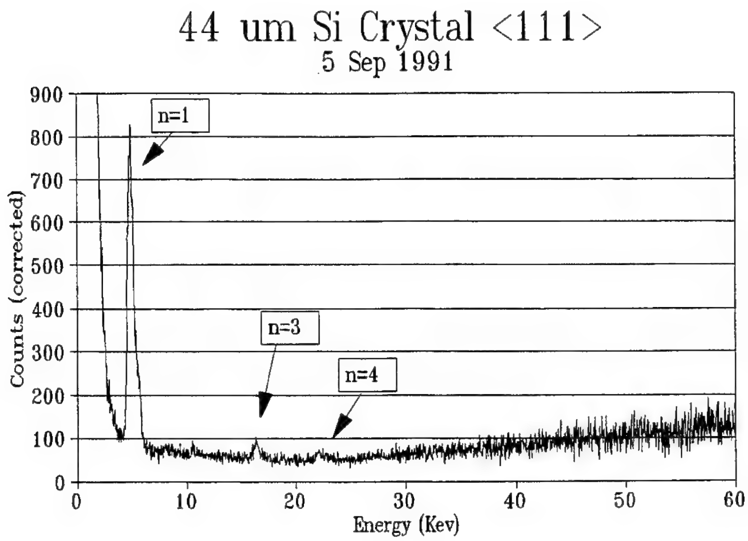
Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	8.088892034	4.343694373	1.86221482	-0.4230524	16.60083647
Ctr	34.26709478	0.063396517	540.5201457	34.14286237	34.39132719
Wid1	0.102491436	0.063862772	1.604869835	-0.02265465	0.227637526

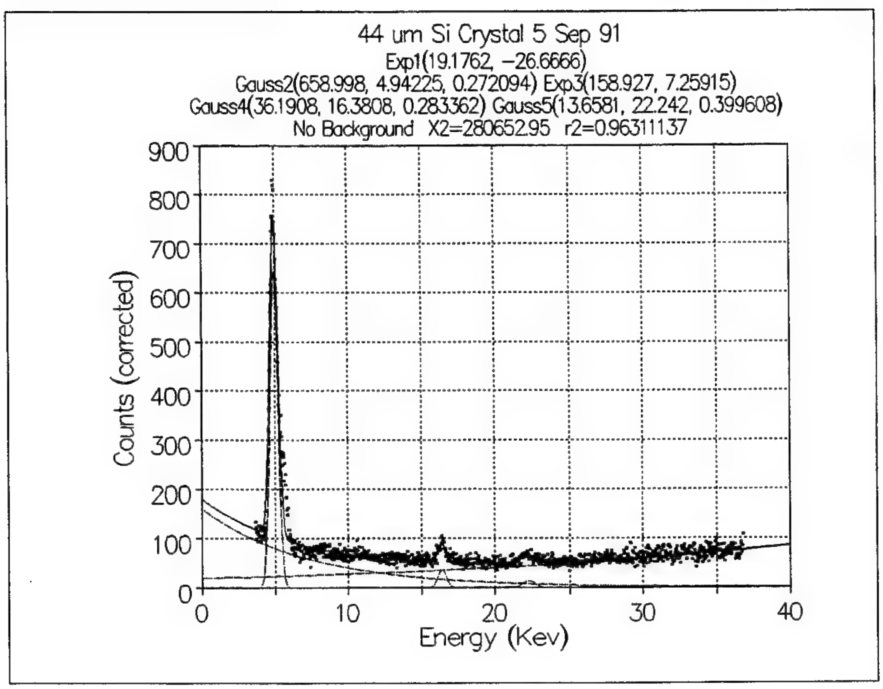
Total Peaks= 7   Coefficient Count= 19   Fitted Count=19

Std Error for Curve= 8.250690594   r2= 0.9282256264

Source	Sum of Squares	DF	Mean Square	F
Regr	938473.36	18	52137.409	765.894
Error	72566.772	1066	68.073895	
Total	1011040.1	1084		

E8. CORRECTED SILICON DATA TAKEN 05 SEPTEMBER 1991





PeakFit Numerical Summary

Description: 44 um Si Crystal 5 Sep 91
X-Y Table Size: 1916 Active Points: 993
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: S905T44.PRN

Curve-Fit Std Error= 16.9227822 r2= 0.963111367

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	19.176236	-26.66662		
2	Gaussian	658.99824	4.9422514	0.2720942	
3	Exp	158.92712	7.2591474		
4	Gaussian	36.190783	16.380823	0.283362	
5	Gaussian	13.658097	22.242023	0.3996076	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Gaussian	658.99824	4.9422514	0.6407329	449.46398	91.943016
3	Exp	0	0	0	0	0
4	Gaussian	36.190783	16.380823	0.667265	25.705739	5.258404
5	Gaussian	13.658097	22.242023	0.9410016	13.680875	2.7985801
	Total				488.8506	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	19.17623649	3.221667458	5.952270601	12.86137518	25.49109781
Rte1	-26.6666154	3.507501612	-7.60273788	-33.5417465	-19.7914842

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
658.9982391	4.942251359	0.640732865	449.4639844
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
4.621884914	5.262617779	0.320366445	0.32036642

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	658.9982391	5.669149315	116.2428792	647.8860147	670.1104635
Ctr	4.942251359	0.002617762	1887.967908	4.937120225	4.947382493
Wid1	0.272094245	0.002910913	93.47383532	0.2663885	0.277799991

Peak# 3 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	158.927118	9.30384888	17.08186795	140.690439	177.1637971
Rte1	7.259147447	0.729310663	9.953436606	5.82960956	8.688685334

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
36.19078254	16.38082348	0.667264951	25.70573938
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
16.04719086	16.71445581	0.333632622	0.33363233

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	36.19078254	5.382078198	6.72431377	25.64125257	46.74031251
Ctr	16.38082348	0.048333088	338.9153091	16.28608473	16.47556223
Wid1	0.283362	0.049316049	5.745837459	0.186696527	0.380027473

Peak# 5 Gaussian

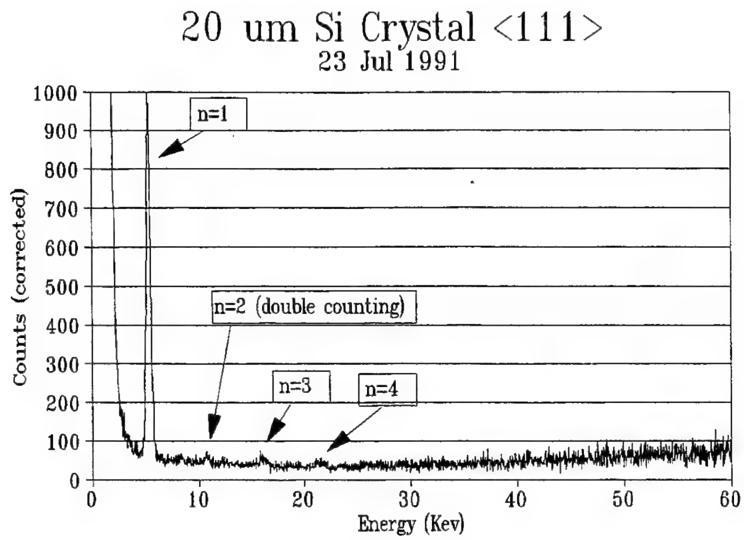
PkAmpl	PkCtr	Wid@HM	Area
13.65809679	22.24202326	0.941001625	13.68087541
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
21.77152236	22.71252399	0.470500894	0.470500731

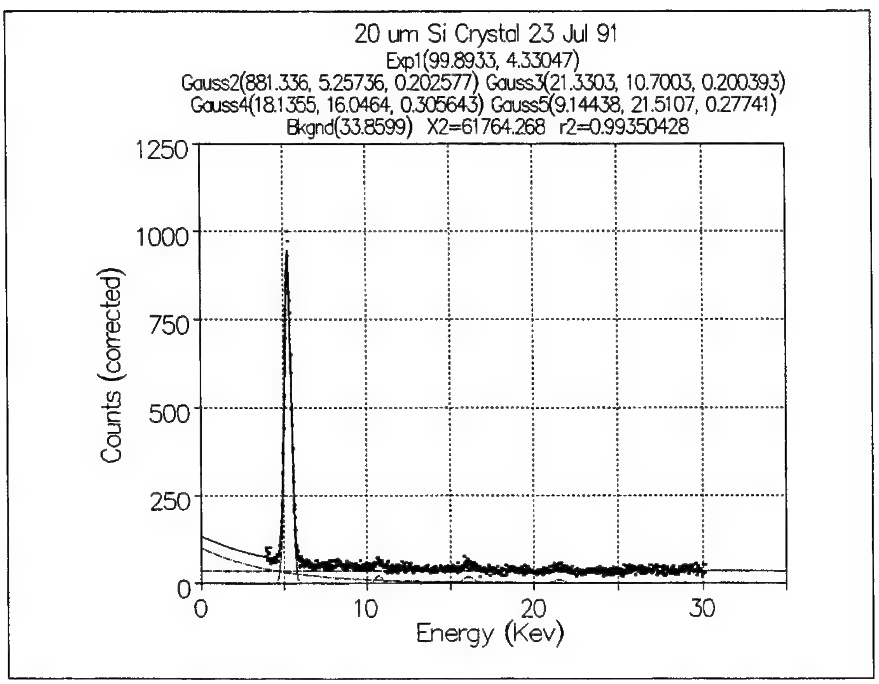
Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	13.65809679	4.554691273	2.998687721	4.730346148	22.58584744
Ctr	22.24202326	0.152088846	146.2436194	21.94391056	22.54013595
Wid1	0.399607571	0.157334203	2.539864583	0.091213335	0.708001807

Total Peaks= 5 Coefficient Count= 13 Fitted Count=13
Std Error for Curve= 16.9227822 r2= 0.9631113669

Source	Sum of Squares	DF	Mean Square	F
Regr	7327461.6	12	610621.8	2132.2
Error	280652.95	980	286.38056	
Total	7608114.5	992		

E9. CORRECTED SILICON DATA TAKEN 23 JULY 1991





PeakFit Numerical Summary

Description: 20 um Si Crystal 23 Jul 91
X-Y Table Size: 1952   Active Points: 846
X Variable: Energy (Kev)
Y Variable: Counts (corrected)
File Source: S723T20.PRN

Curve-Fit Std Error= 8.62120827   r2= 0.99350428

Background Coefficients [y=a+bx+cx^2+dx^3]

Background	a	b	c	d
Order= 0	33.859902			

Curve-Fit Coefficients

Peak#	Type	Ampl	Rte1	Amp2	Rte2
1	Exp	99.893337	4.330475		
2	Gaussian	881.33565	5.2573613	0.202577	
3	Gaussian	21.330343	10.700282	0.2003925	
4	Gaussian	18.135484	16.046351	0.3056427	
5	Gaussian	9.1443786	21.510675	0.2774097	

Measured Values

Peak#	Type	PkAmpl	PkCtr	Wid@HM	Area	%Area
1	Exp	0	0	0	0	0
2	Gaussian	881.33565	5.2573613	0.4770317	447.53122	93.528238
3	Gaussian	21.330343	10.700282	0.4718878	10.714436	2.2391786
4	Gaussian	18.135484	16.046351	0.7197326	13.894189	2.9037059
5	Gaussian	9.1443786	21.510675	0.6532486	6.3586593	1.3288776
	Total				478.4985	100

Peak# 1 Exp

PkAmpl	PkCtr	Wid@HM	Area
0	0	0	0
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
0	0	0	0

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	99.89333723	9.512101224	10.50171091	81.23915734	118.5475171
Rte1	4.330474988	0.321031873	13.48923691	3.700899443	4.960050532

Peak# 2 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
881.3356451	5.257361253	0.47703171	447.5312174
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
5.018845524	5.495877234	0.238515729	0.238515981

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	881.3356451	3.176387788	277.4647505	875.1064316	887.5648586
Ctr	5.257361253	0.000827453	6353.664473	5.255738534	5.258983971
Wid1	0.202576961	0.000881756	229.7426652	0.200847749	0.204306172

Peak# 3 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
21.33034285	10.70028179	0.471887795	10.71443602
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
10.46433789	10.93622568	0.2359439	0.235943895

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	21.33034285	3.148916022	6.773868437	15.15500424	27.50568146
Ctr	10.70028179	0.033874099	315.8838799	10.6338513	10.76671228
Wid1	0.200392541	0.034721221	5.771471546	0.132300761	0.268484322

Peak# 4 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
18.13548436	16.04635095	0.719732616	13.89418909
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
15.68648514	16.40621776	0.359865806	0.359866811

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	18.13548436	2.542285696	7.133535143	13.14980836	23.12116035
Ctr	16.04635095	0.049209914	326.0796398	15.94984539	16.1428565
Wid1	0.305642729	0.050017387	6.110729603	0.20755364	0.403731817

Peak# 5 Gaussian

PkAmpl	PkCtr	Wid@HM	Area
9.144378603	21.51067526	0.653248611	6.358659321
XL @HM	XR @HM	Ctr-XL@HM	Ctr-XR@HM
21.18405111	21.83729972	0.326624155	0.326624456

Parm	Value	Std Error	t-value	95% Confidence Limits	
Ampl	9.144378603	2.669719848	3.425220294	3.908791518	14.37996569
Ctr	21.51067526	0.092963417	231.3886035	21.32836472	21.6929858
Widl	0.277409672	0.09462303	2.931735238	0.091844465	0.462974878

Background Order=0 Area=888.64821091

Parm	Value	Std Error	t-value	95% Confidence Limits	
a	33.85990172	0.523527445	64.67645979	32.83321215	34.88659129

Total Peaks= 5 Coefficient Count= 15 Fitted Count=15

Std Error for Curve= 8.621208271 r2= 0.99350428

Source	Sum of Squares	DF	Mean Square	F
Regr	9446691.8	14	674763.7	9078.53
Error	61764.268	831	74.325232	
Total	9508456	845		

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